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PUBLIC HEALTH ASSESSMENT

TARACORP/NL INDUSTRIES

GRANITE CITY, MADISON COUNTY, ILLINOIS

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SUMMARY

The Taracorp/NL Industries site (Taracorp) is a National Priorities List site in Granite City, Madison County, Illinois that borders the towns of Madison and Venice. This area is part of the Mississippi River flood plain known as the American Bottoms. Taracorp was a secondary lead smelter from 1903 to 1983. In 1983, it ceased secondary lead smelting as the result of continued violations of lead air standards, but continues to operate the metal refining and fabrication facilities. Taracorp was placed on the National Priorities List in 1984. Homes are within one block of the site. Elevated levels of lead resulting from past site operations and disposal practices have been detected in residential and commercial soils in Granite City, Madison, and Venice.

The Illinois Department of Public Health (IDPH) concludes that the Taracorp site poses a public health hazard because of chronic exposure of the public (especially children) to lead, cadmium, antimony, and arsenic in on-site and off-site soils. The primary lead exposure concern for children living near the site is from contaminated off-site soil and off-site air. Airborne lead levels in the neighborhoods surrounding the site may pose a health threat through inhalation and ingestion. Off-site lead contamination of soil may be the result of past smelter stack emissions and fugitive dust generated from the waste piles and on-site soil. Off-site soil lead levels near the site boundary are as high as 20,000 parts per million, with lead levels decreasing with distance from the site. Site-related lead contamination appears to have affected an area greater than four square miles around the site.

A lead exposure study conducted by IDPH in 1991 concluded that house dust served as a major vector of lead exposure in small children living near the site. The source of lead in house dust was lead in paint and soil. The study suggested that soil was a small but statistically significant contributor to blood lead levels in children. The soil lead levels in many off-site areas are greater than background and may serve as a source of exposure to area residents, especially children. Levels of detectable cadmium in the urine of young children ages 6 months through 71 months were 18 times more likely to occur near Taracorp compared with other studies.

Vegetables grown in soils with high lead levels may have higher lead concentrations than those grown in soil with lower lead levels. Garden plants, especially leafy vegetables, continue to receive some lead by deposition of airborne, lead-contaminated dust. This source probably does not greatly contribute to overall lead exposure; however, contaminated soil or dust that is not rinsed from vegetables could increase the ingestion of lead. Plants are known to take up cadmium and arsenic from soil. The rate of cadmium uptake by plants and the concentration in vegetables is not known. Inorganic arsenic taken up by plants may be transformed to an organic form that is less toxic.

Although site-related contaminants affect area groundwater, groundwater is not used as a drinking water source. The city supply is drawn from the Mississippi River and is unaffected by site-related contamination.

BACKGROUND

A. Site Description and History

Lead and associated inorganic contaminants are known to exist in and next to the Taracorp site because of industrial operations at this facility over a period of 80 years. The site was placed on the National Priorities List (NPL) in 1984. A remedial investigation was completed in 1988, and a feasibility study was completed in August 1989. A final Record of Decision (ROD) was signed in March 1990. The ROD required cleanup of lead-contaminated soils and battery chips at the site and at residential properties, and capping of the Taracorp pile. The ROD was reopened for review and public comment in 1994. In September 1995, the U.S. Environmental Protection Agency (USEPA) issued a Decision Document/Explanation of Significant Differences. Groundwater monitoring was added to the reopened ROD, but the other conclusions remained essentially the same.

The Taracorp site is on 16th Street south of Niedringhaus Avenue in Granite City, Madison County, Illinois (Figure 1). Presently, the site covers less than 18 acres, but historic information shows that Hoyt Metal Company (a previous owner) operated on 30 acres. The site borders properties owned by Trust 454, Terminal Railroad Associates Inc., Illinois Central Gulf Railroad, Chicago and Northwestern Railroad, and Tri-Cities Trucking Inc. St. Louis Lead Recyclers (SLLR) is a tenant of Trust 454 (Figure 2). The site is on the Mississippi River flood plain known as the American Bottoms. The site is not within the 100-year flood plain because of a levee system along the Mississippi River.

Metallico, the current owner, continues lead processing; however, on-site activities were greatly reduced in 1983 in an effort to reduce lead air emissions. Subsequent decreases in the price of lead further reduced production. A slag storage area is found on the southern boundary of the site. A preliminary site assessment performed in May 1983 estimated the quantity of lead waste to be 250,000 tons. Most of this waste is in and around the slag storage area. The slag storage area is known to contain slag, metallic lead, lead oxide, other lead compounds, cadmium, arsenic, iron oxide, silica, rubber and plastic battery cases, general refuse, drums, and matte. Matte is a by-product of smelting that contains metal sulfides and metal oxides.

Site operations started in 1895 as the Markle Leads Works, which manufactured lead shot and clay pigeons. In November 1900, fire destroyed most of the facility. In 1901, the plant was rebuilt and included a lead smelter. Before 1903, processes at the site included the manufacturing of lead shot, sealing wax, mixed metals, rolled sheet metal, and dross refining. Dross is the term for the waste products or impurities on the surface of molten metal. United Lead purchased the smelter in 1903. After 1903, secondary smelting capabilities were added. Secondary smelting is the process of smelting lead-bearing materials other than ores. N.L. Industries, formerly the National Lead Company, acquired the smelter in 1928. Battery recycling began in the 1950s. In

1979, N.L. Industries sold the site to Taracorp Industries. Taracorp Industries sold the site to the present owner Metallico.

Taracorp has a secondary smelter with a capacity to produce 22,000 tons of lead products per year. In 1983, Taracorp ceased secondary smelting. Taracorp continues to operate the metal refining and fabricating facilities at the site. The facility produced lead products by recycling lead-bearing scrap materials. The lead products produced at Taracorp Industries included sheet lead, solder, shotgun pellets, lead wool, and secondary lead ingots.

SLLR borders Taracorp on its southwest boundary. SLLR was built in 1980 and was originally designed to reclaim lead from batteries. In 1982, SLLR reached an agreement that allowed them to recycle various materials from Taracorp. Between 1981 and 1983, SLLR processed approximately 11,000 tons of the Taracorp slag pile. Materials that could not be recycled (e.g., slag and hard rubber) were placed southwest of the slag pile. In June 1983, SLLR stopped recycling lead from the slag pile. The pile has remained undisturbed since that time.

USEPA began the remediation of contaminated alleys and driveways in April 1993. The cleanup level of 500 parts per million (ppm) of lead in soil included about 1,300 properties. The city of Granite City filed a Temporary Restraining Order-Permanent Injunction in Federal Court limiting the USEPA cleanup because the city believed that removing contaminated soil would not greatly reduce the residents' exposure to lead in the environment. The request for a Restraining Order was denied by a Federal judge on August 22, 1996, allowing USEPA to continue with the full cleanup. As of late 1998, about 1,100 properties had their soils remediated.

B. Site Visit

The Illinois Department of Public Health (IDPH) has visited the site many times since 1983. The most recent site visit was conducted in December 1996. The dominant site feature is the huge slag pile that covers nearly 5 acres at the southern end of the property. The slag pile rises more than 40 feet above grade in some areas and is estimated to weigh more than 250,000 tons. The pile is unprotected from the elements, although company representatives have stated the pile has been treated chemically to reduce wind erosion. The type of chemical used and its efficacy are unknown. The remainder of the site consists of various occupied and unoccupied buildings, railroad tracks, pavement, and bare soil. There are many pieces of heavy equipment, some abandoned, on adjacent properties. Thousands of broken battery cases, large pieces of metal slag, barrels, and construction debris are visible on the surface of the pile. A chain link fence encloses the facility. The site has been accessible in the past through an open gate on the SLLR property; however, the gate is currently locked at night.

Due to continued industrial operations at the site, trespassing is unlikely. Although a determined trespasser could gain access during such times, there are no reports or evidence of trespass. There is evidence of vegetative stress along the edge of the slag pile, perhaps due to battery acid or metal pollution; however, several small trees and grasses are growing on the pile itself. The neighborhood is a mixed residential, commercial, and industrial area with the closest homes located a few hundred feet east of the site (Figure 1).

C. Demographics, Land Use, and Natural Resource Use

The population within a 3-mile radius of the site is about 30,500, and includes all of Venice (population 3,570), Madison (population 4,630), and about two-thirds of Granite City (population 32,770). The estimated population within a 1/2-mile radius is approximately 8,000, and the population within a 1/4-mile radius is approximately 4,000. In 1980, the number of children 5 years old and younger in Granite City, Madison, and Venice was 3,301. The estimated number of children 5 and under within a 3-mile, 1/2-mile, and 1/4-mile radius is 2,445, 312, and 156, respectively.

The closest residents are within 100 yards of the Taracorp property line. The neighborhood directly east of the site consists of multiple and single family dwellings. A hospital and seven schools are found within a 1-mile radius of the site, and are within the proposed cleanup areas. The adjacent properties to the south, west, and north are zoned for industrial use. Industries to the south are SLLR, Commonwealth Steel Co., and Illinois Power Co. BV&G Transport is next to the site on the southeast side. National Steel Corporation is next to the site on the west side and is separated by railroad tracks. The industries that border the site to the northeast are S.M. Wilson and Co., Nesco Steel Barrel Co., Hubbell Metals, and Granite City Steel.

Recreational activities that may occur within a 1-mile radius of the site would be limited to playground activities at an elementary school and playing in yards and empty lots. There are no parks or recreational bodies of water within 1 mile of the site.

D. Health Outcome Data

Taracorp has been the focus of considerable attention and concern over the past decade. At least three screenings of potentially exposed populations have been conducted since the late 1970s. IDPH sampled residents of Granite City and Madison in late 1982, and sampled residents of Venice in late 1983. The studies were undertaken because of concern about the high lead levels measured in air while the smelter was in operation. In response to concern generated by the planned remedial action and in recognition of new information about the hazards of lead exposure, IDPH and the Agency for Toxic Substances and Disease Registry (ATSDR) began a large epidemiological study of lead exposure in these communities in 1991. The evaluation of these studies is presented in the *Public Health Implications* section of this document.

The Granite City Lead Exposure Study was conducted by IDPH in the summer and fall of 1991. The study was performed under a grant from ATSDR and was done to determine if site-related lead exposure was occurring in the population surrounding the site. The study area included

Granite City, Madison, and Venice. Sources of lead examined in the study included soil, paint, dust, and water.

COMMUNITY HEALTH CONCERNS

In 1983, public attention and concern were raised because Taracorp repeatedly exceeded acceptable ambient air levels of lead and was listed as an NPL site. Concern diminished during the period 1983-1990 when no apparent regulatory activity was underway at the site. In early 1990, USEPA conducted a series of public meetings culminating in a public hearing to discuss their proposed remedial action for the Taracorp site and to take public comments. At that time, the preferred alternative in the Record of Decision (ROD) was excavation of all off-site residential soils having lead levels at or above 500 ppm. The soil was then to be placed atop the slag pile, and the entire pile was to be capped. Public reaction was mixed on this remedial alternative. The majority of area citizens preferred full removal to the capping of the Taracorp pile.

Community concerns included:

1) What are the effects of lead on health?
2) Why are children more sensitive to lead's effects?
3) Where does lead come from and how does exposure to lead occur?
4) Is lead exposure related to cancer?
5) Are garden vegetables safe to eat?
6) Will blood tests for lead be made available?
7) What is the basis for the 500 ppm lead cleanup level?
8) Is the remedial action necessary?

Additional concerns mainly focused on the remedial action's effects on property values and the desire to be rid of the slag pile rather than the creation of a bigger pile. According public comments received by USEPA, the residents were divided with concern to the residential yard cleanup and the majority of the residents preferred removal of the Taracorp pile over the capping alternative. Additional groundwater data caused USEPA to reopen the ROD. The conclusions of the reopened ROD were the same as the original ROD, with the addition of a groundwater containment system.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

IDPH compared the concentration of each contaminant detected during environmental sampling with the appropriate comparison value developed by the Agency for Toxic Substances and Disease Registry (ATSDR). These comparison values are used to select contaminants for further evaluation for exposure and any resulting carcinogenic and non-carcinogenic health effects. Chemicals found at levels greater than comparison values or those for which no comparison value exists were selected for further evaluation.

The comparison values used to select contaminants for further evaluation include Environmental Media Evaluation Guides (EMEGs), Cancer Risk Evaluation Guides (CREGs), Reference Dose Media Evaluation Guides (RMEGs), Lifetime Health Advisories (LTHAs), and Maximum Contaminant Levels (MCLs).

EMEGs are developed for chemicals based on their toxicity, frequency of occurrence at National Priority List (NPL) sites, and potential for human exposure. They are derived to protect the most sensitive populations and are not action levels, but rather comparison values. They do not consider carcinogenic effects, chemical interactions, multiple route exposure, or other media-specific routes of exposure, and are very conservative concentration values designed to protect sensitive members of the population.

RMEGs are another type of comparison value derived to protect the most sensitive populations. They do not consider carcinogenic effects, chemical interactions, multiple route exposure, or other media-specific routes of exposure, and are very conservative concentration values designed to protect sensitive members of the population.

CREGs are estimated contaminant concentrations based on a probability of one excess cancer in a million persons exposed to a chemical over a lifetime. These are also very conservative values designed to protect sensitive members of the population.

LTHAs have been established by USEPA for drinking water and are the concentration of a chemical in drinking water that is not expected to cause any adverse non-carcinogenic effects over a lifetime of exposure. These are conservative values that incorporate a margin of safety.

MCLs have been established by USEPA for public water supplies to reduce the chances of adverse health effects from contaminated drinking water. These standards are well below levels for which health effects have been observed and take into account the financial feasibility of achieving specific contaminant levels. These are enforceable limits that public water supplies must meet.

Chemicals released near the site by other industries were determined by examination of the USEPA's Toxic Chemical Release Inventory (TRI). This database contains self-reported information on releases of materials to air, water, land, and other information. These data were examined for Granite City (Zip Code 62040), Madison (Zip Code 62060), and Venice (Zip Code 62090). In 1993, total emissions were 520,725 pounds per year to the air, 77,392 pounds per year to waterways, and 4,662,979 pounds per year in landfills. The top five companies with highest releases were (from highest to lowest) Granite City Steel, Precoat Metals, Reilly

Industries, Spectralite Consortium, and Granite City Pickling. The breakdown of area releases by company, compound, and amount of release per medium are found in Table 1.

A. On-site Contamination

The contaminants found on the site are mainly inorganic chemicals. Because of to the history of the site, most samples were not analyzed for organic chemicals. Slag pile, soil, groundwater, air, and surface water samples were collected on the site. Slag pile, drum, soil, and groundwater analyses were performed by the Illinois Environmental Protection Agency (Illinois EPA) from 1982 to 1983, and by O'Brien and Gere in 1987. O'Brien and Gere also analyzed surface water and sediments in 1987. Air monitoring was conducted by the Occupational Safety and Health Administration (OSHA) in 1987, and by Taracorp from 1987 to1988. Because access to the site is restricted to Taracorp employees, the comparison values used for the waste piles, slag, surface soil, and drummed material were for adults.

1. Waste Pile Analyses

Samples were taken in January 1987 from the two largest slag piles and some drums (Figure 3). In the largest slag pile, both the upper layers and actual slag were sampled. All samples were analyzed for antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Of these, no comparison values have been developed for copper, lead, mercury, or zinc. Analyses for organic compounds were not performed on these samples.

a. Slag from Largest Waste Pile

The largest waste pile was divided into four quadrants. A composite sample was taken from four locations in each quadrant. Table 2 lists the chemicals of interest for slag in the largest waste pile. Mercury levels were below detection limits in the slag samples.

Two of the slag samples were analyzed for extraction procedure (EP) toxicity. EP toxicity was done to determine if the slag is a hazardous waste for arsenic, cadmium, chromium, and lead. Results of the EP toxicity samples are given in Table 3. The slag is considered a hazardous waste based on the EP toxicity values for lead.

b. Upper Layers of the Largest Waste Pile

Ten samples were taken from the material on top of the largest slag pile. The samples were filtered in the field through a 9.5 millimeter (mm) sieve. The purpose of sieving these samples was that the 9.5 mm fraction includes those particles that would be small enough in size to be transported by wind or runoff under extreme weather conditions. The chemicals of interest in the upper layers of the slag pile are listed in Table 4. Five of the samples were analyzed for EP toxicity of arsenic, cadmium, chromium, and lead. Four of the five samples were EP toxic for lead, and one of five were EP toxic for cadmium (Table 5).

c. Surface Materials from SLLR Pile

In 1987, O'Brien and Gere took three samples from the SLLR slag pile (Figure 3). The chemicals of interest for the SLLR pile are listed in Table 6 and are the same ones listed for the largest slag pile. The SLLR pile was expected to be very similar in composition to the largest slag pile since it is wholly or in part a sub-sample of that pile.

One sample from the SLLR pile was analyzed for EP toxicity of arsenic, cadmium, chromium, and lead. This sample was sieved through 9.5 mm opening screens. Lead was EP toxic in the SLLR pile (Table 7).

2. Drummed Material

In May 1983, Illinois EPA took two drum samples and analyzed them for metals and EP toxicity. The chemicals of interest are shown in Table 8. The EP toxicity of the drummed material was analyzed for arsenic, cadmium, chromium, and lead. The results in Table 9 show that lead was EP toxic in both samples, and cadmium was EP toxic in one sample.

O'Brien and Gere took two samples of drummed material from the top of the waste pile in January 1987 (Table 8). The cadmium and lead concentrations in one drum were 2,700 ppm and 23,700 ppm, respectively. The total lead concentration in the other drum was 237,000 ppm.

Only three drums were sampled at Taracorp, and they may not represent the contents of all the drums. Approximately 30 drums were observed during field investigations of the piles. Although more drums may be buried in the piles, they are probably a very small percentage of the total waste on the site, so their total contribution to exposure from the Taracorp waste pile is small.

3. Soil

A. Surface Soil

In August 1982 and January 1983, Illinois EPA collected six on-site surface soil samples. Surface samples were defined as samples taken from 0 to 6 inches in depth. O'Brien and Gere performed a soil investigation of the Taracorp site in January 1987. The on-site soil sample in this survey consisted of two samples (0 to 3 inches deep and 3 to 6 inches deep) at one location. The soil sample was analyzed for total lead concentration. The location and lead concentrations of the six Illinois EPA samples and the surface soil sample taken by O'Brien and Gere in 1987 are shown in Figure 4. The lead concentrations in these samples ranged from 14,800 ppm to 300,000 ppm.

In 1988, the archive samples from the 0 to 3 inch range were analyzed for antimony, arsenic, cadmium, chromium, lead, and zinc. The analysis results between the first samples and the archived samples showed a wide discrepancy in the lead levels; however, the variation between the lead analyses of the archive samples and the original samples was deemed to be within an acceptable range. The greatest variation was in the lone on-site soil sample. The first sample analysis shows the lead concentration of the on-site sample, 0-3 inches, was 1,550 ppm; however, the archive sample analysis was 14,800 ppm.

The on-site chemicals of interest are listed in Table 10. Since only one sample was taken, and was analyzed for chemicals other than lead, it probably does not accurately reflect on-site soil contaminant concentrations.

B. Subsurface Soil

In October 1982, subsurface soil samples were taken at Taracorp from the monitoring well boring of well 101 (Figure 5). Six samples were taken from depths between 4.0 and 30.5 feet and were analyzed for lead. The concentrations of lead varied from 13 ppm at the 29 to 30.5-foot depth and 2,700 ppm at the 14 to 15.5-foot depth. The sample was only analyzed for lead because it was expected to be the main contaminant.

In May 1983, on-site soil samples were taken from monitoring well borings (Figure 5). Samples were taken from the boring at various depths from 0 to 35 feet deep. In all, 40 separate samples were taken from the 4 borings. The boring samples were analyzed for antimony, arsenic, lead, magnesium, and zinc. The samples were taken horizontally to characterize the soil on the site.

The subsurface soil samples from all five boring locations were divided into two depth groups: 1 to 20 feet and greater than 20 feet. Table 11 lists the chemicals of interest in the subsurface samples at these two depths. The high value of the range for lead in the 1 to 20-foot sample was taken from boring 1 at a depth between 14.0 and 15.5 feet. This suggests that lead may be migrating vertically through the soil.

4. Groundwater

The initial on-site groundwater investigation began in October 1982. At that time, four monitoring wells, G101 - G104, were installed at Taracorp. Two of those wells, G101 and G104, were installed on the site. Groundwater samples taken from G104 (a downgradient well) in November 1982 showed the presence of lead at 50 parts per billion (ppb). This information prompted Illinois EPA to install eight more wells, consisting of four sets of shallow and deep wells, in July 1983 (Figure 5). At each location, the shallow well was installed at the surface of the water table, which is 22 to 26 feet below grade. The deep wells were installed 3 to 5 feet from the shallow wells and 10 to 15 feet deeper than the shallow wells. The sampling dates of the on-site monitoring wells, along with other pertinent data, are given in Table 12. The chemicals analyzed for in the samples taken in 1982 and 1983 were arsenic, boron, cadmium, chloride, total chromium, copper, fluoride, iron, lead, manganese, nickel, silver, sulfate, and zinc.

O'Brien and Gere took additional samples of on-site groundwater from these wells in January, April, August, and November 1987. After the January 1987 sampling round, wells 105S, 106S, and 108S did not contain enough water to sample. All the samples were analyzed for sulfate, total dissolved solids, and the following filterable metals: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Filterable metal sample analyses removes some suspended material and thus may underestimate the total metal concentrations in groundwater. Total lead concentration was analyzed in samples from wells 101, 102, 106D, and 108D.

Chemicals of interest in groundwater are shown in Table 13. All wells contained a chemical at a level greater than the adult comparison value at least once during monitoring. Groundwater flow in the Granite City area is generally west-southwest. Groundwater pumping in the Granite City area has disrupted the general groundwater flow patterns. Upgradient, on-site wells might include 101, 105S, and 105D; however, these wells also contained some contaminants. Wells 108S and 108D had the highest levels of contamination and are downgradient of the waste piles and near the battery breaking operations.

Lead was detected in 16 of 40 on-site groundwater samples and in all on-site wells except 105S, 105D, and 106S. Cadmium exceeded the comparison value in one of every four on-site samples and was detected at least once in five wells. Nickel concentrations equaled the comparison value in 9 of 45 samples. Nickel was found in three on-site wells, two of which were deep. Arsenic exceeded the comparison value in 11 of 45 samples from two on-site wells. Sulfates exceeded the comparison value in 15 of 45 samples in five different wells. The contamination of deep wells by more than one contaminant suggests that the inorganic compounds may be migrating through the soil and into the groundwater.

5. Surface Water and Sediment

Four samples of storm runoff from the slag pile, including water and sediments, were collected in May 1987 (Figure 6). The samples were only analyzed for lead content. Surface water runoff also was collected on the site. Lead analysis of the samples ranged from 3 to 41 ppm. For comparison, the standard for lead discharge into a waterway is 0.2 ppm. Sediment samples were also collected during runoff from the slag area in the same locations as the surface runoff samples. Lead levels in the samples ranged from 5,400 ppm to 97,000 ppm.

6. Air

OSHA has performed air monitoring in the workers' breathing space at different on-site work locations from December 1987 to February 1988. All 28 samples were analyzed for lead, and 27 samples were analyzed for arsenic. Antimony and tin were analyzed in one air sample. OSHA allows a permissible exposure limit (PEL) for lead in air of 0.2 milligrams per cubic meter (mg/m^3) in an occupational setting, provided workers wear protective clothing and a respirator. The PEL without protection is 0.05 mg/m^3, and the action level set in these areas is 0.03 mg/m^3. Four of 18 samples taken in the 0.2 PEL areas exceeded the standard.

Arsenic was also sampled in the workers' breathing space. The OSHA standards for arsenic are a PEL of 50 micrograms per cubic meter ($\mu g/m^3$) and an action level of 5 $\mu g/m^3$. The results of the December 1987 to February 1988 OSHA inspection of Taracorp indicate that arsenic levels exceeded the PEL in 1 of the 28 samples and exceeded the action level in 5 of 28 samples.

Besides the 1987 OSHA air samples, Taracorp had individual workers participate in a personal monitoring program for lead and arsenic exposure in 1987. The samples were taken quarterly, and the results of the personal monitoring program are shown in Table 14. The individuals are grouped by department. One hundred persons participated in the personal monitoring program for lead. The mean air lead concentration over four quarters exceeded the PEL of 0.2 mg/m^3 in four departments: Mixed Metals "A"; Mixed Metals "A" Dross; Maintenance; and Powdered Metals/Flux. The National Ambient Air Quality Standard (NAAQS) for lead in air is 1.5 $\mu g/m^3$. The NAAQS for lead was exceeded in every department.

The personal monitoring program for arsenic was also conducted quarterly, and the results are presented in Table 15. Twenty-six individuals from five departments participated in the arsenic personal monitoring program. The mean arsenic concentration for the personal monitoring program in 1987 exceeded the PEL of 0.05 mg/m^3 in two of the five departments.

7. Biomonitoring

Workers' blood lead levels were monitored for a 13-month period from December 1986 to December 1987. Samples were to be taken at least once a month and more frequently if the blood levels exceeded 50 micrograms per deciliter ($\mu g/dL$). Often, the sampling of individuals was not performed monthly. The reason for this lack of sampling is unknown.

One hundred twenty people participated in the blood monitoring program. Three people had blood lead levels greater than 50 $\mu g/dL$ at least once during the sampling period. Twenty-two people had blood lead levels above 40 $\mu g/dL$ during the sampling period. The blood samples ranged from <10 $\mu g/dL$ to 56 $\mu g/dL$, with a mean of 24 $\mu g/dL$. The mean represents 740 samples from a possible 1,196 monthly samples.

B. Off-site Contamination

Inorganic chemicals including arsenic, cadmium, chromium, lead, nickel, and zinc have been studied off the site. Lead has been the most extensively studied. Off-site analysis includes soil, air, groundwater, vegetables, household dust, drinking water, and blood.

1. Soil

Off-site soil sampling in areas surrounding the site has been performed on four separate occasions. Illinois EPA performed the first sampling event in 1982. The second sampling event was performed by O'Brien and Gere in 1987 and 1988. In 1989, IDPH took 40 samples. Illinois EPA took the most recent samples north-northeast of Taracorp in and around the Jennison-Wright site. These samples were taken within 6 inches of the surface and are called surface soil samples. The locations of these surface soil samples can be seen in Figure 7.

In 1982, soil samples were taken from neighborhoods surrounding the smelter. Four types of samples were taken. These samples (and the number of each sample type) were: bare surface soil (7), soil with vegetated surfaces (36), subsurface soil (2), and garden soil (6).

In 1987, 52 surface soil samples were taken from off-site locations. Forty-one surface soil samples were taken within a 0.5-mile radius of the site. The remaining 11 samples were collected from the remote fill areas in Venice and Eagle Park Acres, where chips of battery casings from the site were used as paving and fill materials. Two soil samples were taken at depths of 0 to 3 inches and 3 to 6 inches from each location within the half-mile radius. These samples were originally analyzed for lead only. The 0 to 3 inch archive samples were analyzed not only for lead, but also for antimony, arsenic, cadmium, chromium, and zinc. There were discrepancies between lead concentrations in samples that should have been identical. In comparing the first and second analyses, all but four of the lead concentrations in the first analyses were higher. The differences between the analyses ranged from 0 to 13,250 ppm. The mean of the differences was 820 ppm with a standard deviation of 2,184 ppm. One sample was analyzed for EP Toxicity but was not found to be a hazardous waste.

In October 1987, IDPH collected four soil samples in Granite City. The locations of these samples were: Grand Avenue between 15th and 16th Streets; 16th Street between Delmar Avenue and Edison Avenue; 20th and Delmar; and 23rd and Madison. These samples were analyzed for arsenic, cadmium, chromium, lead, and nickel.

In 1989, IDPH collected 40 soil samples surrounding the site. Some of these samples were taken in areas that had been previously sampled by O'Brien and Gere. These samples were taken for comparison with the O'Brien and Gere samples because of the discrepancy between analyses of identical samples by their laboratory. Other samples were taken in each block south and east of the site for a distance of two blocks. The samples were analyzed for arsenic, cadmium, chromium, lead, nickel, and zinc content.

In 1991, as part of the Madison County Lead Study, 375 off-site soil samples were collected by USEPA. These samples were analyzed for cadmium and lead. The results of the lead samples are similar to the other off-site soil samples and are summarized in Table 16.

The off-site chemicals of interest are listed in Table 17. The comparison values used are based on children with pica behavior (ingestion of an unusually large amount of non-food items). Copper, manganese, mercury, and selenium were not analyzed in the off-site surface soils. Antimony, arsenic, and cadmium exceeded the comparison values in every sample. Chromium and nickel exceeded the comparison values in some soil samples.

Lead levels generally decreased as distance from the site increased. Table 18 shows the lead concentration ranges based on increasing distance from the site. In 1983, Illinois EPA created a map showing the concentration of lead in surface soils near the site (Figure 8). The map depicts the highest concentration of lead in off-site soils to be in those areas closest to the site. The lead concentrations on this map coincide reasonably well with samples taken after the map was created.

2. Groundwater

Groundwater was monitored in off-site wells from 1982 to1983 and again in 1987. Wells 102 and 103 were constructed by Taracorp in November 1982. Two additional monitoring wells, 109 and 110, were installed by O'Brien and Gere in July 1987 (Figure 5).

The chemicals of interest in off-site monitoring wells are shown in Table 19. Cadmium was present in one sample from well 103 and in both samples from well 110. Lead in wells 102 and 103 indicates off-site groundwater contamination. Well 110 is considered upgradient of the site, and the source of cadmium in this well is unknown.

The 1988 remedial investigation identified at least 36 wells within a 2-mile radius of the site (Figure 9). In addition, IDPH, Illinois EPA, and USEPA conducted a door-to-door search for residential wells within a 1-mile radius downgradient of the site. One well was found in a residential area approximately 0.25 miles from the site. The well in the residential area was not used for drinking water. Sample results from this off-site well were not found and it is unknown whether it is currently in use.

3. Air

Illinois EPA has performed air monitoring at 11 locations between 1977 and 1990 throughout the Granite City area, with most air monitors used for five years or less. Six of the longer-running air monitoring sites, as seen in Figure 10, are: (1) Roosevelt and Rock Road; (2) 19th and Adams; (3) 17th and Cleveland; (4) 15th and Madison; (5) 23rd and Madison; and (6) 2001 E. 20th. The distance and direction of these air monitors from the site are as follows: (1) Roosevelt and Rock

Road - 1 5/8 miles, north; (2) 19th and Adams - 7/8 of a mile, northeast; (3) 17th and Cleveland - 1/4 of a mile, northeast; (4) 15th and Madison - 1/4 of a mile, southeast; (5) 23rd and Madison - 1 7/8 miles, northeast; and (6) 2001 E. 20th - 9/10 of a mile, east. A summary of lead in air sampling results is listed in Table 20.

Table 20 shows a steady decline in the ambient air lead levels at all monitoring sites between 1977 and 1990. This decline may be due to variety of factors including decreased use of leaded gasoline, loss of industries in Granite City, and the closure of the secondary smelter and SLLR reclamation activities in the pile in 1983.

The NAAQS for lead is 1.5 $\mu g/m^3$ per quarter. The yearly averages exceeded the standard five times: four times at 15th and Madison and once at 19th and Adams. The NAAQS has not been exceeded since the first quarter in 1984 at the monitor at 15th and Madison.

Ambient air data were divided into two time frames, 1977 to 1982 and 1983 to 1990. The purpose of this division was because Taracorp ceased its secondary smelting operation and SLLR suspended waste pile reclamation in 1983. Air levels before 1983 would be most representative of past exposures with data collected after 1982 representing current and future exposures. Table 21 contains the ambient off-site air data in the Granite City area between 1977 and 1982. The values used in the ranges are yearly arithmetic means for that year. The column labeled "highest mean" gives the year of the highest mean for the specified period and the location number of that mean. The location number refers to the sampling location in Figure 10. Arsenic exceeded the comparison value in air for the period. No comparison value exists for lead, copper, or zinc in air.

Table 22 contains information on ambient air concentrations from 1983 to 1990. Nickel and chromium exceeded the comparison value at the 2001 E. 20th Street location. Selenium had its highest yearly arithmetic mean concentration of 0.012 $\mu g/m^3$ at the 15th and Madison and 2001 E. 20th Street locations. Since selenium was not found in the on-site areas above detection limits, the source of selenium in the air is not known. Arsenic exceeded its air comparison value at all locations. Lead and selenium were detected at several locations, but neither have an air comparison value.

Air monitoring for zinc and copper was discontinued in 1978. Antimony was not detected in any of the samples. Air monitoring began for selenium in 1984 and chromium in 1985.

4. Vegetables

Vegetable samples were taken in the fall of 1982 from gardens near Taracorp. The samples were analyzed for lead by a U.S. Food and Drug Administration (FDA) laboratory. Table 23 contains the vegetable analysis results and the soil lead concentrations of each garden. The locations of the gardens near Taracorp are shown in Figure 11. Background vegetable samples, with soil lead concentrations of 97 ppm and 53 ppm, were taken from the northeast side of Granite City.

Vegetables were prepared before analysis by washing them with distilled water and peeling vegetables that are normally peeled before eating.

The lead concentrations in the tomatoes, banana peppers, and okra from the two control areas were similar. All the vegetable samples taken from the control areas (areas with lower soil lead concentrations) had lower lead concentrations than those taken from neighborhoods adjacent to the site. Vegetable lead levels generally decreased with a decrease in soil lead concentration. The lead levels of selected vegetables from an FDA market basket survey of four different regions of the U.S. have much lower lead levels than the vegetables taken from gardens near the site.

Arsenic and cadmium and were not analyzed in vegetables taken from the garden samples since the primary site-related contaminant was lead. Both arsenic and cadmium are taken up by plants.

5. Drinking Water

In 1991, 373 "first draw" drinking water samples were collected from households that participated in the Madison County Lead Study. The first draw sample was taken from the tap after it had not been used for at least 8 hours. The first draw samples allow any lead in the pipes to leach into the tap water and would be expected to represent the highest lead concentrations in the tap water. Table 16 contains summary information on the tap water sample results. The lead levels in tap water samples from Granite City had a range from below detection (<2.0 μg/L) to 96 μg/L. Ten samples had lead levels above the action level of 15 μg/L. The mean lead concentration in the tap water was 3.3 μg/L.

Nine of the ten water samples with lead concentrations above 15 μg/L were redrawn after first letting the tap water run until the temperature stabilized, indicating that the water had come from the water main. All nine second drawn water samples had lead levels less than the detection limit of 2.0 μg/L of lead. The results indicate that the water is probably contaminated by lead in the household plumbing. These residents were instructed to run their water a few minutes prior to using it for drinking or cooking.

6. Household Dust

Household dust was taken from 371 households and the dust loading factor (dust sample weight divided by surface area then multiplied by the dust lead concentration) was calculated for 367 households. The mean dust loading factor for the household was 885 $\mu g/m^2$. A summary of the dust sample results is presented in Table 16.

7. Paint

Indoor and outdoor paint samples were taken from 372 and 380 households, respectively. The samples were analyzed using an XK-3 X-ray fluorescence instrument. Eighteen readings were taken indoors and 12 readings were taken outdoors. The mean indoor and outdoor readings were 1.2 mg/cm^2 and 5.3 mg/cm^2, respectively. A summary of the paint sample results are given in Table 16.

8. Biomonitoring

In 1991, 827 residents of Granite City, Madison, and Venice participated in the Madison County Lead Study. A breakdown of participants by age is given in Table 24. Four hundred ninety (490) of the participants were in the target age range of 6 - 71 months. Table 25 shows the blood lead distribution of the children age 6 months to 71 months who have blood lead levels greater than or equal to 10 µg/dl. The total number of children in that age range with blood lead levels at or above 10 µg/dl was 78, which represents 16% of the children in that age range.

C. Quality Assurance and Quality Control (QA/QC)

The remedial investigation for the Taracorp site followed an approved Quality Assurance Project Plan that included quality assurance objectives for measurement data concerning precision, accuracy, and completeness for the various matrices analyzed. The quality control objectives were intended to be consistent with those established for the USEPA Contract Laboratory Program for inorganic compounds. Any deviations from the QA/QC plan are contained in Appendix E of the RI report. The QA/QC information for Illinois EPA and IDPH samples were not found.

D. Physical and Other Hazards

Most of the on-site physical hazards are restricted to the worker population and consist of those risks common to industrial operations. These include risks of injury or death from falls, burns, crushing injuries, and associated trauma. Vehicular traffic in and around the site may be heavy and pose a risk to workers and pedestrians. The fact that the site is an active operation and fenced serves to discourage trespass; however, open gates and damaged fencing may allow access during periods of inactivity. Abandoned buildings on or next to the site may be attractive to area children or other trespassers.

PATHWAYS ANALYSES

To determine if nearby residents are exposed to site-related contaminants migrating off the site, IDPH evaluates exposure pathway components. An exposure pathway consists of five elements: 1) a source of contamination, 2) transport through an environmental medium, 3) a point of exposure, 4) a route of human exposure, and 5) an exposed population. If any of these elements are missing, the exposure pathway is not complete.

Completed pathways require that the five exposure elements exist and that exposure has occurred in the past, is currently occurring, or will occur in the future. Potential pathways have at least one element missing, but the missing element(s) could exist. Potential pathways suggest that exposure could have occurred in the past, could currently be occurring, or could occur in the future. An exposure pathway is eliminated if one or more of the elements are missing and will never be present. Table 26 identifies the completed exposure pathways, and Table 27 identifies the potential pathways.

A. Completed Exposure Pathways

Surface Soil Pathways

Past, current, and future exposure to contaminated on-site and off-site soils is assumed to be occurring at several exposure points including residential yards, playgrounds, and on-site soil. Bare areas at these exposure points may greatly increase exposure because it allows direct contact to and disturbance of the soil.

Contamination of the surface soils may have occurred by several mechanisms including airborne deposition from the waste piles, contaminated soils, site operations, and SLLR activities; surface runoff; and tracking and fugitive dust generation from vehicles. Air deposition of site contaminants is illustrated by the lead soil concentration map (Figure 8), which shows that lead concentrations decrease with increased distance from Taracorp.

Past exposure of workers to on-site surface soils has surely occurred. Using protective clothing and proper hygiene should greatly reduce or eliminate current and future exposures to contaminants in on-site soils by employees or site remediation workers. Exposure may occur by ingestion and inhalation.

Exposure in residential yards has surely occurred in the past and continues to occur. Those most susceptible to exposure to contaminated residential soil are small children who play in the soil, especially those children closest to the site playing in soil with almost no groundcover. Ingestion would be the primary route of exposure, especially with younger children. Inhalation may also be a route of exposure, especially when surface soils are dry.

The site-related contaminants that residents would most likely contact in the soil would be the same ones that have high concentrations in the waste piles and those that were in the smelter stack emissions. These contaminants would include antimony, arsenic, cadmium, chromium, lead, nickel, and zinc. Of these contaminants, lead has the highest concentration in the waste and off-site soils. The number of persons that would be most highly exposed to off-site soil contaminants would be the approximately 8,000 persons within a 1/2-mile radius of the site.

Since the shutdown of Taracorp smelting operations in 1983, the primary routes of lead exposure to area residents have been through the ingestion and inhalation of contaminated soils and dust. In addition to the possible contribution of maternally-derived lead from long-term female residents of the area, another important source of site-related lead exposure to the most sensitive segment of the population (preschool children) has been directly or indirectly through soil and dust contamination. This exposure consists primarily of:

- direct ingestion of contaminated soil by children,
- transfer of contaminated dusts to mouth by hands,
- swallowing of inhaled airborne particulates too large to penetrate to the lung,
- ingestion of food or liquids contaminated by lead-containing soils or dusts, and
- inhalation of lead-contaminated particulates small enough to penetrate to the lung.

Additional exposure to lead may be occurring through old exterior and interior paints, plumbing, dietary sources (particularly canned foods), tobacco smoke, and parental occupations or hobbies. Given the air emissions originating from the smelter and the long half-life of lead in the body, long-term residents of the area may have received a significant lead exposure.

Ambient Air

Past, current, and future exposures have occurred and will continue to occur from the Taracorp waste piles, site operations, and contaminated soils both on and off the site. Past exposures, and to a lesser extent current and future exposures, will occur from plant process operations on the site. Past exposures may also have been higher than the present, since the piles were disturbed, especially with excavation by SLLR. Future remediation of the site also may increase airborne exposure.

Ambient air monitoring, especially for lead, has been conducted in the Granite City area since 1977. The air data seem to show a decline in some inorganic chemicals including lead. The reduction in lead in ambient air coincides with the cessation of secondary smelting at Taracorp and closure of SLLR. Other factors may have contributed to this decline including phasing out leaded gasoline and the decline of industry in Granite City. Areas with the highest inorganic ambient air contaminants are at 15th and Madison and 2001 E. 20th Street. Another source of lead near Taracorp and these air monitors is Granite City Steel. The yearly arithmetic mean for ambient air lead levels have not exceeded the NAAQS level of 1.5 $\mu g/m^3$ since 1981 at the 15th and Madison location. At the same location, the NAAQS was last exceeded in the first quarter of 1984. The NAAQS may be reduced in the future based on additional data review.

Many residential yards and a gravel parking lot next to the site boundary owned by Tri-Cities Trucking may allow contaminated soil and dust to become airborne, especially on windy days. The waste piles and soil on the Taracorp property are currently uncovered and winds may move contaminated soils and dust to residential areas.

The population affected by the site would include workers on the site and residents in areas surrounding the site. Exposure of on-site workers and adjacent populations to lead would likely occur by both inhalation and ingestion. Inhalation of lead on the site would occur by breathing suspended dirt and waste pile particles and possibly by breathing fumes and dusts from on-site processes. Ingestion of lead by workers would likely be accidental; however, inadvertent ingestion may occur indirectly from inhalation. Inhalation would occur off the site by breathing contaminated dust and soil from the waste pile and on- and off-site soil. Release from the waste pile is reduced by treatment with a dust suppressant twice per year. Ingestion of contaminated soil would occur accidentally by adults and children, but ingestion of contaminated soil by children may be a significant route of exposure.

Vegetable and Fruit Pathways

Past, present, and future exposures may occur in residents who garden or eat fruits and vegetables grown near Taracorp. Past exposures to inorganic chemicals on fruits and vegetables would come from contaminated soil and airborne deposition. The airborne concentrations of some contaminants, especially lead, were much higher near the site before 1983. Deposition of lead on vegetables may contribute more to their inorganic content than from uptake from the soil. In 1982, vegetable samples were taken in the neighborhoods near Taracorp. The results of these samples showed that the lead in vegetables correlated with soil lead levels. These areas of higher soil lead are closer to the site and deposition also may add to the lead concentration in these vegetables. Airborne deposition of inorganic contaminants on local fruits and vegetables probably continues, but to a lesser degree than in the past.

The contribution of vegetables to exposure to inorganic compounds will depend on several factors including the percentage of the diet made up of homegrown vegetables and vegetable preparation (e.g., washing). Lead was the only inorganic compound chosen for analysis in vegetables, but plants also take up both arsenic and cadmium. The rate of uptake is dependent on a variety of factors including pH, phosphorus, and other metals present in the soil. Inorganic arsenic taken up by plants may be converted to an organic form that is less toxic than the inorganic form. The number of gardeners near Taracorp is not known.

Waste Pile

Exposure to the waste pile has occurred from activities associated with the pile including adding, moving, and removing materials. Taracorp and SLLR employee exposures to waste pile contaminants are certain to have occurred in the past. Disturbing the waste piles in any way is currently prohibited. The waste pile is scheduled to be capped in the future.

B. Potential Exposure Pathways

Groundwater

Past, present, and future exposures to site-related contaminants in groundwater are possible. Migration of chemicals off the site may be occurring; however, the extent of the contamination is not fully known. In the past, residents may have had private wells, but off-site groundwater contamination in the past may not have existed. Currently no residential drinking water wells were identified within 0.25 miles downgradient of the site. All residents in Granite City, Madison, and Venice use municipal water and exposure to groundwater is unlikely. Future exposures are unlikely to occur since municipal water is available to all area residents.

Surface water

Surface water runoff from the site enters the storm sewers, and is treated at the municipal water treatment plant before being released to the Mississippi River. No surface water bodies are contaminated by the site, since all surface runoff water enters the storm sewers. In the area between the site boundary and the storm sewers, children could be exposed to contaminants by ingestion and dermal contact if allowed to play in the contaminated storm water runoff. Since such exposures would likely be infrequent and at low levels, this pathway is not expected to pose a health hazard.

Waste Pile

Exposure to waste pile contaminants could occur in the future if the waste pile is disturbed during remediation. This could potentially represent a very significant exposure to both workers and residents near the site. The waste piles have very high concentrations of inorganic contaminants, especially antimony, arsenic, cadmium, lead, and zinc. The number of residents that would be exposed would be at least those within 0.5 miles of the site (approximately 8,000 persons) and an unknown number of on-site workers.

PUBLIC HEALTH IMPLICATIONS

A. Toxicological Evaluation

To evaluate health effects, ATSDR has developed Minimal Risk Levels (MRLs) for chemicals commonly found at hazardous waste sites. An MRL estimates the daily human exposure to a contaminant below which adverse, non-cancer health effects are not likely to occur. MRLs are developed for different routes of exposure, and for three different exposure periods: acute (less than 14 days), intermediate (15-365 days), and chronic (more than 365 days). At Taracorp, the only site contaminant that has an MRL is cadmium. When an MRL is not available for a contaminant of concern, a USEPA reference dose (RfD) was used, if available. RfDs are used for long-term exposure, and may not be protective of hypersensitive individuals. ATSDR has developed Toxicological Profiles for contaminants that are common at hazardous waste sites.

The profiles contain information on health effects, environmental transport, human exposure, and regulatory status of each chemical.

IDPH considers three types of individuals when evaluating exposure: adults, children, and pica children. Adults have larger body weights, breathe more air, and ingest less soil than children. Pica children have excessive hand-to-mouth activity and are prone to ingest more soil than a typical child. Exposure to soil is reduced somewhat by the fact that the ground is frozen during winter months. Exposure to all site-related chemicals in soil may be inhaled or ingested.

Lead

Most of the health effects associated with lead are the result of chronic, low level exposures. Acute effects of lead intoxication are similar to chronic effects, but occur rarely. Acute effects can be severe and include encephalopathy, which may result in death. Chronic effects of lead intoxication vary depending on exposure levels. Some health effects attributed to lead exposure are interference with Vitamin D production, neurobehavioral toxicity, renal dysfunction, and, at higher exposures, dysfunction of cardiovascular, hepatic, gastrointestinal, and endocrine systems. USEPA presently classifies lead as a B2 carcinogen for both inhalation and ingestion. There is evidence that it is a carcinogen in animals at high doses; however, there is insufficient evidence that lead caused cancer in humans. Animal data suggest that lead is not a very potent carcinogen.

The greatest concern for lead is based on its effects on the nervous system, particularly in young children. Lead's effects on nervous system development was recognized early in this century, but was assumed to be reversible until the 1940s when researchers reported permanent effects on learning and behavior in children exposed to lead. A continual reduction in the acceptable body burden has accompanied the expanding knowledge of the adverse effects of lead. The acceptable level of lead in children's blood has dropped from 60 μg/dL in the 1950s to the current Centers for Disease Control and Prevention (CDC) level of 10 μg/dL. This does not imply that a safe level of blood lead has been identified. In the last few years, several studies have been conducted and are still ongoing that suggest children may suffer neurological and developmental deficits at blood lead levels well below the current standard. While not universally accepted, these studies seem to suggest that prenatal and postnatal exposures at levels of 10-15 μg/dL are associated with low birth weight, reduced growth rate, cognitive deficits, and a reduction in neurologic development as measured by IQ. Needleman and his co-workers have suggested that if children with elevated blood lead experience an average drop of four IQ points, the number of individuals with IQs less than 80 would triple and those with IQs above 125 would vanish.

Children are prone to lead exposures higher than adults and are much more sensitive to the neurological effects. The differences that increase a child's sensitivity to lead include an increase in lead intake into the respiratory and gastrointestinal tract on a body weight basis; greater absorption and retention rates; differences in behavior, including hand to mouth activity;

increased lability of lead in a child's body; and greater prevalence of nutrient deficiency of those nutrients that affect absorption in the gastrointestinal tract.

Studies also show that the fetus is at risk from environmental lead exposure as well. Pregnancy and lactation may mobilize the lead from maternal bone stores in a manner identical to calcium mobilization. Lead will cross the placenta and the fetus may serve as a place for the mobilized maternal lead to accumulate. In women of childbearing age, pregnancy and lactation may serve to mobilize bone lead to the detriment of the fetus and infant.

While much attention has focused on the hazard of lead to the fetus and child, additional studies are suggesting chronic health risk to adults as well. Some studies have shown that elevated blood lead levels in middle-aged males may increase their risk of developing hypertension. It has also been suggested that lead may aggravate osteoporosis in postmenopausal women when bone lead stores are released by the demineralization processes. There is a considerable body of animal and epidemiological evidence pointing to the serious chronic health problems posed by lead exposure; however, the relative importance of different environmental lead sources is unclear.

The hazards posed by lead in the home, workplace, and environment are undisputed and current research suggests that lead may have deleterious effects at lower levels than previously thought, and that many children may be at risk from lead. There is a question, in fact, about whether there is a threshold for the adverse effects of lead. The degree to which lead in soil poses a hazard and the magnitude of that hazard is not as clear, and may depend on numerous socioeconomic and behavioral factors besides the lead content of soil. The concern over soil lead concentrations arises over the observation that direct soil contact may result in inadvertent soil ingestion by children that may, in turn, significantly increase lead exposure. Some studies have linked children's blood lead to the lead levels in exterior and interior soils and dusts. The significance of this relationship appears to vary widely, but a positive relationship is always seen. Potential confounders were obviously not completely considered in many of these studies, but they do often illustrate the interdependence between environmental sources and socioeconomic factors.

Arsenic

The population exposed to arsenic would be the same as those exposed to lead. Exposure may occur by ingestion or inhalation. Adverse health effects associated with arsenic are most notably that it is a known human carcinogen by inhalation and ingestion. Using standard exposure assumptions, the RfD is exceeded for the pica child, child, and adult exposures to arsenic in soil.

The highest concentration of arsenic in surface soils was taken along Taracorp's northeastern boundary. If persons were exposed to this soil, only 2 of 77 the surface soil samples might lead to exposure that exceeds the oral RfD for adults. Thirty-one of 72 surface soil samples might lead to exposure that exceeds the RfD for exposed children. All 77 surface soil samples had arsenic levels that might lead to exposure greater than the RfD for exposed pica children (Table 28). If this soil is ingested at these levels, symptoms may occur.

The noncarcinogenic effects that may be associated with inorganic arsenic may include irritation of the stomach and intestines with symptoms including nausea, vomiting, and diarrhea, a decrease in the production of red and white blood cells, abnormal heart function, blood vessel damage, and impaired nerve function causing a "pins and needles" sensation in the hands and feet.

Long-term ingestion of arsenic may also lead to a pattern of skin changes including a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. These skin changes are not necessarily a health concern by themselves, but they may later develop into skin cancer. Chronic ingestion of arsenic has also been reported to increase the risk of liver, bladder, kidney, and lung cancers.

There is evidence that inhalation of inorganic arsenic causes lung cancer in humans. The range of yearly arithmetic mean concentrations for the 13 years that arsenic has been monitored in the Granite City area is 0.002-0.039 μ/m^3. A low increased risk of lung cancer from arsenic exposure existed at that time for persons who breathed this air in Granite City.

Antimony

Antimony was found in off-site soil at levels from 2 ppm and 80 ppm. Five of 39 off-site soil samples had antimony levels that might lead to exposure that would exceed the oral RfD for exposed children. All thirty-nine samples had antimony levels that might lead to exposure that would exceed the oral RfD for an exposed pica child. Antimony was not analyzed in either on-site or off-site air. Exposure to antimony on the site and near Taracorp may cause adverse health effects including irritation to the eyes, skin, and lungs, and sometimes heart problems, vomiting, and diarrhea.

Cadmium

Seventy-seven surface soil samples taken near Taracorp were analyzed for cadmium. All cadmium levels might lead to exposure that exceeds the chronic oral MRL for an exposed pica child, while 5 of 77 samples contained cadmium at levels that might lead to exposure greater than the chronic MRL for exposed children. Cadmium would not be a health hazard to exposed adults. Health effects that may be associated with oral cadmium exposure are a build-up of cadmium in the kidney that may cause kidney damage and fragile bones. This build-up of cadmium in the kidneys is also observed in inhalation exposures. While ambient airborne concentrations of cadmium did not exceed the MRL for cadmium in air, it affects the body in the same way as ingested cadmium and provides an additional exposure.

The yearly range of arithmetic means for ambient air concentrations between 1977 and 1990 was 0.003 - 0.011 $\mu g/m^3$. The data on cadmium inhalation and cancer in humans are limited. Based on the available information, no apparent increased cancer risk would be expected in Granite City due to exposure to airborne cadmium.

Chromium

Chromium exists in several forms the environment including chromium III and chromium VI. Chromium III is the naturally occurring form and is an essential nutrient. Chromium VI is usually associated with industrial activities. Chromium analyses in both air and soil samples did not differentiate between chromium III and chromium VI. Even if all the chromium in the soil is chromium VI, the exposure to chromium in the soil is not a health hazard for adults and children. Exposure to chromium in the soil by a pica child may exceed the RfD in 75 of 77 samples (Table 28). The health effects associated with chromium in off-site soils would not be expected to cause any problems in the general population; however, allergic individuals may have redness and swelling of skin if they come into contact with soils with high chromium levels.

The airborne concentrations of chromium in ambient air based on yearly arithmetic means between 1985 and 1990 were 0.002-0.032 $\mu g/m^3$. Intermediate and chronic health effects associated with breathing chromium could appear in the population near 2001 E. 20th Street. This assumes that all the chromium is chromium VI, and this is probably not the case. Chromium is not expected to produce adverse health effects in most individuals; however, persons who are allergic to chromium may have asthma attacks.

Long-term exposure to elevated chromium levels in the workplace has been associated with lung cancer. Chromium VI seems to be at least one form of chromium associated with lung cancer, while chromium III is not. The levels of chromium identified in the ambient air in Granite City are less than for those individuals working with chromium.

Nickel

Thirty-eight soil samples taken near Taracorp were analyzed for nickel. The range of nickel in the soil was 14 to 84 ppm. Exposure to nickel at these levels would not be a health hazard for children and adults. Oral exposure to nickel in soil for a pica child was estimated to equal or exceeded the RfD in 8 of 38 samples. The health effects associated with nickel at higher levels are increased red blood cells and protein in urine from damage to the kidneys. In an allergic person, skin contact with nickel can cause a skin rash.

Ambient airborne nickel concentrations in Granite City were from 0.001 to 0.021 $\mu g/m^3$. Nickel and certain nickel compounds are lung, nasal, and sinus carcinogens. These cancers have been identified in workers who work with airborne nickel concentrations of 1,000 $\mu g/m^3$ or greater.

The levels of nickel found in Granite City air are much lower. No apparent increased cancer risk would be expected due to exposure to nickel in air.

Zinc

Zinc is an essential nutrient. The health effects associated with zinc are non-carcinogenic and have been reported in individuals ingesting and inhaling zinc at higher levels than those that would be encountered in Granite City. The health effects from breathing high levels of zinc in the workplace include breathing difficulties and may cause a brief sickness called metal fume fever. At very high levels, breathing zinc dust or fumes may be life threatening. Ingestion of too much zinc can cause anemia and digestive problems. Excessive zinc intake may also be associated with an increased risk of heart disease and trouble in fighting disease or infection.

B. Health Outcome Data Evaluation

Three studies were conducted by IDPH because of concern over the high lead concentrations measured in air while the lead smelter was in operation. The first study sampled residents of Granite City and Madison in late 1982. The second study sampled residents of Venice in late 1983. The results of the blood lead and erythrocyte protoporphyrin (EP) testing are as follows (both measured in micrograms per deciliter):

1982 - Granite City/Madison

	N	Blood Lead (μg/dL)			EP (μg/dL)		
Ages		Range	Mean	Median	Range	Mean	Median
0-5	47	1-37	13.2	11	1-76	31.9	15.5
6-10	3	8-24	14	10	1-24	14.3	18
11-20	4	7-16	10.3	9	11-21	14.0	17
21-60	45	2-28	9.6	8	1-53	16.5	17
Total	99	1-37	11.5	10	1-76	17.5	15.5

1983 - Venice

	N	Blood Lead (μg/dL)			EP (μg/dL)		
Ages		Range	Mean	Median	Range	Mean	Median
0-5	31	4-27	9.1	7	21-56	31.2	30
6-10	10	5-10	6.9	6	19-33	27.4	28.5
11-20	36	4-18	7.0	7.5	14-79	31.9	28
21-60	47	5-15	9.0	7	16-93	34.6	34
61+	12	4-13	7.4	6	29-51	36.5	34
Total	136	4-27	8.4	7	14-93	32.5	32

The mean blood lead levels for children in the U.S. based on the NHANES II study for ages 0.5 to 5.0 years was 16 μg/dL. The results of the blood lead testing in 1982-1983 suggest no unusual elevation in these children.

No attempt was made to correlate blood lead levels to exterior soil lead levels, although some attempt to identify interior lead sources was made in individuals identified as having high blood lead (then defined as 30 μg/dL). The utility of this work in assessing the hazards posed by environmental lead has been called into question due to:

1) the small numbers of individuals (especially children) sampled, and
2) the time of year (late fall) that the sampling was conducted.

In response to concern generated by the planned remedial action and in recognition of new information about the hazards of lead exposure, IDPH and ATSDR began a large epidemiological study of lead exposure in these communities in 1991. Eight hundred twenty-seven people from the area surrounding the site participated in the Madison County Lead Exposure Study. More than 600 children provided biological samples submitted for lead testing and other biomedical analyses. Of these, 490 children under the age of six participated in the study. Environmental sampling also was conducted at the homes of these children. This sampling included soils, household dust, drinking water, and interior and exterior paint analyses. The results of the biological monitoring were correlated with questionnaire data in an attempt to discern which factors are the most important determinants of lead body burdens. The conclusions of the study were:

1) most children under the age of six years had blood lead levels of concern (>10 μg/dL),
2) that house dust served as a major vector of lead exposure in small children living near the site and the source of lead in house dust was the lead in paint and soil,

3) soil lead levels had a small but statistically significant contributions on the variance on the child's blood lead level, and

4) many personal variables influence lead uptake (i.e., behavior, socioeconomic status, education, and smoking) and variables present at a particular house.

Sixty percent of the lead uptake was unaccounted for by variables used in the study.

The youngest age group of children 6 months to 71 months in the Madison County study was 18.7 times more likely to have detectable urine cadmium levels greater than 0.1 µg/g creatinine than were young children in study areas in Pennsylvania, Missouri, and Kansas. This observation could not be explained by different cadmium levels in environmental media or urine cadmium levels. The urine cadmium levels were also not associated with any personal behavior variables in the four-state study. This may show a small but detectable cadmium exposure in young children in the area surrounding Taracorp.

Lung cancer incidence for Granite City, Madison, and Venice were compared with those of Madison County, Illinois. The age adjusted lung cancer rates for the zip codes for Granite City (62040), Madison (62060), and Venice (62090) based on a five-year average from 1990 to 1994. The rates are number of deaths from lung cancers per 100,000 persons in the population. The data is broken down by sex but not by race due to the small sample size in the zip codes. The age-adjusted cancer rates were used with population data from the 1990 census. Both the county and zip code data were adjusted to the 1970 cancer rates so that they could be compared. This standardized rate ratio method to calculate the observed rate (zip code) and the expected rate (county) is a useful indicator of the relative exceedances of cases in the study group. This comparison is not a statistical test. Generally, 0.8 to 1.2 is similar or approximate the rate in the reference group. If a zip code has fewer than 10 cases of a particular cancer, the rates are not considered stable or reliable.

The rates ratio for Granite City, Madison, and Venice for both men and women are:

Age Adjusted Lung Cancer Rate Ratios			
	Granite City	Madison	Venice
Male	1.01	1.60	0.0
Female	1.82	1.29	2.7

The sample numbers for men and women in Venice were N=0 and N=4, respectively, both of which were too small to assess the lung cancer rates ratio. The rate ratio for males in Granite City was the only one that was within the expected rate. The rate ratio for lung cancer in both males and females in Madison and females in Granite City are slightly above the expected range; however, this does not necessarily indicate an elevation in lung cancers. A cluster investigation in Granite City and Madison may eliminate bias and would explain the slight increase in the ratio over the expected rates.

Skin cancer rate ratios could not be determined from the data received by the IDPH Division of Epidemiological Studies. Their data base does contain melanoma information for the state and counties, but it is not currently available for zip codes. In addition, only melanomas were recorded and not other skin cancers. The skin cancer types most frequently associated with arsenic exposure are squamous cell carcinomas and basal cell carcinomas.

C. Community Health Concerns Evaluation

The community health concerns have been addressed as follows:

1. What are the effects of lead on health?

Acute effects of lead intoxication are similar to chronic effects, but occur rarely. Acute effects can be severe and include encephalopathy that may result in death. Most of the health effects associated with lead are the result of chronic low level exposures. Chronic effects of lead intoxication vary depending on exposure levels. Many health effects of chronic low level exposure are very generalized and not easily seen as caused by lead exposure. Some health effects are not observable at all. The best method to detect lead exposure, especially in the most susceptible population (children between the ages of 6 months and 6 years) is to have them screened annually during the months when children are most likely to play outside.

Some health effects attributed to lead are interference with Vitamin D production, neurobehavioral toxicity, and renal dysfunction. At higher exposures, effects include dysfunctions of cardiovascular, hepatic, gastrointestinal, and endocrine systems. USEPA presently classifies lead as a possible human carcinogen for both inhalation and ingestion.

2. Why are children more sensitive to lead's effects?

Children are prone to lead exposures higher than adults and are much more sensitive to the neurological effects. The developing nervous system of a child is much more susceptible to the effects of lead. Children also display adverse health effects at much lower lead exposure than adults.

The differences that increase a child's exposure to lead versus an adult's exposure include:

- An increase in lead intake into the lungs and digestive system on a body weight basis.
- Greater absorption of lead into the body by the digestive system and more difficulty eliminating lead from the body.
- Increased mobility of lead in a child's body.

- A more frequent occurrence of nutrient deficiencies that lead to increased absorption from the digestive system into the body.
- Differences in behavior that increase lead exposure including –
  - Crawling and playing on the floor or ground
  - Placing non-food items into the mouth
  - More hand to mouth activities
  - Lack of hand washing before eating

3. Where does lead come from and how does exposure to lead occur?

Lead is a naturally-occurring metal in the earth's crust. It is used in a variety of products including automobile batteries, ammunition, and some paints. Its use has been reduced or eliminated in many products including solder, paint, and gasoline. Lead in the Granite City area also may come from several industries. The industry that has probably contributed the most lead to the area is Taracorp. Taracorp was the site of a secondary smelter, where lead slag and automobile batteries were smelted to reclaim the lead. Smelting was ceased at this location in 1983. Taracorp still has approximately 250,000 tons of lead-containing waste in several piles on the site.

Lead exposure from the Taracorp site may occur by inhaling lead from on-site operations, wind blown dust, or lead contaminated soils either on or off the site. Additionally, exposure to lead may occur by ingesting contaminated off-site soils or vegetables. Ingestion of soil lead will probably be highest in children under the age of six years, since they have the greatest amount of hand to mouth activity.

4. Is lead exposure related to cancer?

USEPA presently classifies lead as a possible carcinogen for both inhalation and ingestion. There is evidence that it can cause cancer in animals at high doses; however, there is insufficient evidence of its ability to cause cancer in humans. Animal data suggest that lead is not a very potent carcinogen. The U.S. Department of Health and Human Services has determined that lead acetate and lead phosphate may reasonably be anticipated to be carcinogens. Lead acetate and lead phosphate are lead containing compounds that are not associated with the Taracorp site.

5. Are garden vegetables safe to eat?

If the soil is removed from root vegetables and all vegetables are washed to remove air-deposited lead, the vegetables should be safe to eat based on lead exposure. The exposure to other contaminants, particularly cadmium, is not known since vegetables were not analyzed for cadmium concentration. Cadmium is taken up by plants and the extent of this uptake in the garden plants grown near Taracorp is not known.

6. Will blood tests for lead be made available?

Blood tests were made available by IDPH for residents of Granite City, Madison, and Venice as part of the blood lead study. This testing began in August 1991. There are currently no IDPH-sponsored testing of individuals in the Granite City, Madison, and Venice area.

7. What is the basis for the 500 parts per million cleanup level?

The 500 parts per million residential soil cleanup level for lead was set by USEPA. This level was chosen based on factors that are specific to the area around the smelter and the types of lead that were released to the environment from the smelter. USEPA supported this cleanup level in the amended ROD based the USEPA's Integrated Exposure, Uptake, and Biokinetic Model for Lead.

8. Is the remedial action necessary?

Remedial action is necessary for on-site and off-site contamination to remove wastes and soils that contain excessive lead concentrations. The lead cleanup level in soil and the extent of the soil remediation necessary is outside the scope of this assessment.

CONCLUSIONS

The Taracorp site in Granite City, Illinois, poses a public health hazard because chronic exposure to lead, antimony, arsenic, and cadmium in off-site soils may cause adverse health effects in children.

1) A lead exposure study of the population surrounding the site concluded that house dust served as a major vector of lead exposure in small children living near the site and the source of lead in house dust was the lead in paint and soil lead. The study indicated that soil and paint were small but significant sources of lead exposure. This study also indicated that children between 6 months and 71 months of age near the site were 18 times more likely to have detectable cadmium in urine. In addition, children with pica habits may also experience adverse health effects from exposure to nickel and chromium in off-site soils. In addition, airborne cadmium, chromium, and arsenic may increase the risk of lung cancer in area residents.

2) The Taracorp waste pile is exposed to wind and water erosion, which carry contaminants to areas where people contact them. This exposure may be minimized by the use of dust suppressants on the waste pile.

3) On- and off-site remedial activities involving removal of surface soil and waste piles will increase the risk of worker and residential exposure to site-related contaminants through inhalation and ingestion.

4) Workers may be exposed to lead from on-site processes.

5) If the contaminated soil is removed from root crops exposure to lead in homegrown fruits and vegetables is not considered a primary exposure pathway. It is not known if cadmium uptake in homegrown fruits and vegetables is significant.

6) Groundwater contamination is not presently considered a threat to public health based on lack of groundwater consumption in the area and little off-site migration.

7) No surface water bodies are contaminated by site-related contaminants.

RECOMMENDATIONS

1) Remediate waste piles to reduce or eliminate exposure to waste pile contaminants.

2) Reduce exposure to lead by reducing or eliminating exposure sources including dust, lead-based paint, and soil.

3) Provide information to area residents on how to take measures to reduce exposure to contaminants in soil, especially exposures to children. These measures include good hygiene practices, sodding of bare areas of soil, and washing root vegetables.

4) Provide optimal dust control measures during remedial activities.

5) Provide appropriate air monitoring at the work site perimeter to ensure warning if the safety of nearby residents is threatened.

6) Provide appropriate protective clothing for workers that may be exposed to contaminants during site operations and remediation.

7) Collect downgradient monitoring well samples next to the site. These should be analyzed annually to determine contaminant migration.

8) Conduct blood lead screening for children 6 years of age and younger as part of their routine medical care.

9 ~~10~~) Fruits and vegetables grown in local gardens should be analyzed for cadmium levels.

PUBLIC HEALTH ACTIONS

The following actions either have or will be performed to meet the needs expressed by the recommendations of this public health assessment. IDPH, in cooperation with ATSDR, will:

1. Continue to work and consult with Illinois EPA and USEPA on implementation of the recommendations, and on the public health issues that may arise as any action occurs;

2. Continue to inform area citizens and health professionals of the public health issues associated with the site; and

3. Continue to solicit the health concerns of citizens living in the site area directly or through Illinois EPA, USEPA, and public meetings.

PREPARERS OF REPORT

Preparer:

David R. Webb
Environmental Toxicologist
Illinois Department of Public Health

Reviewers:

Ken Runkle
Bruce C. Barrow
Environmental Toxicologists
Illinois Department of Public Health

ATSDR Regional Representative:

Louise Fabinski
Office of Assistant Administrator

ATSDR Technical Project Officers:

Gail Godfrey
William Greim
Environmental Health Scientists
Division of Health Assessment and Consultation

Steve Inserra
Division of Health Studies

Courtney Jones
Division of Health Education and Promotion

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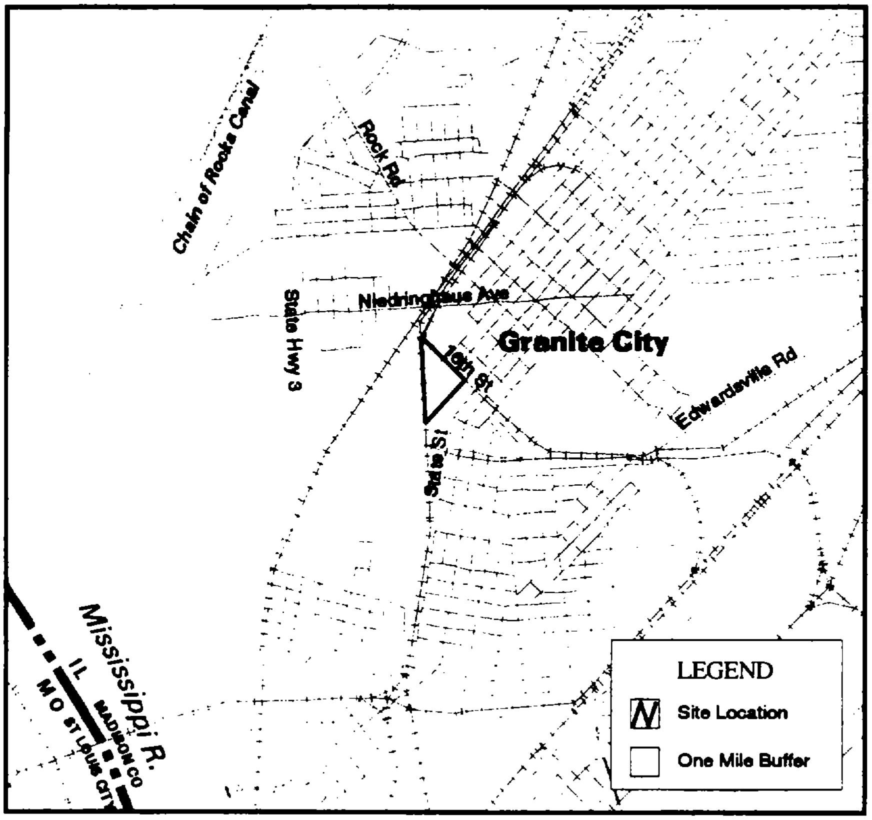
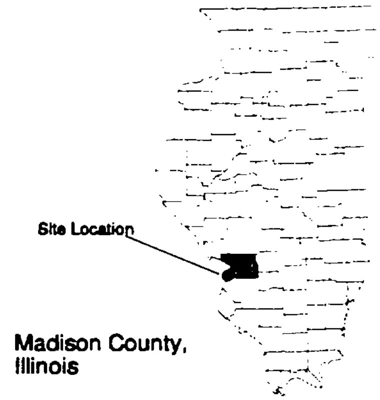
APPENDIX A. FIGURES

Taracorp/N.L. Industries

Granite City, Illinois

CERCLIS No. ILD980704142





Demographic Statistics Within One Mile of Site*	
Total Population	11496
White	10394
Black	912
American Indian, Eskimo, Aleut	55
Asian or Pacific Islander	60
Other race	75
Hispanic origin	259
Children Aged 6 and Younger	1289
Adults Aged 65 and Older	1634
Females Aged 15 - 44	2508
Total Housing Units	5290

*Calculated using an area-proportion spatial analysis technique

Population Density

Children 6 Years and Younger

Adults 65 Years and Older

Females Aged 15 - 44

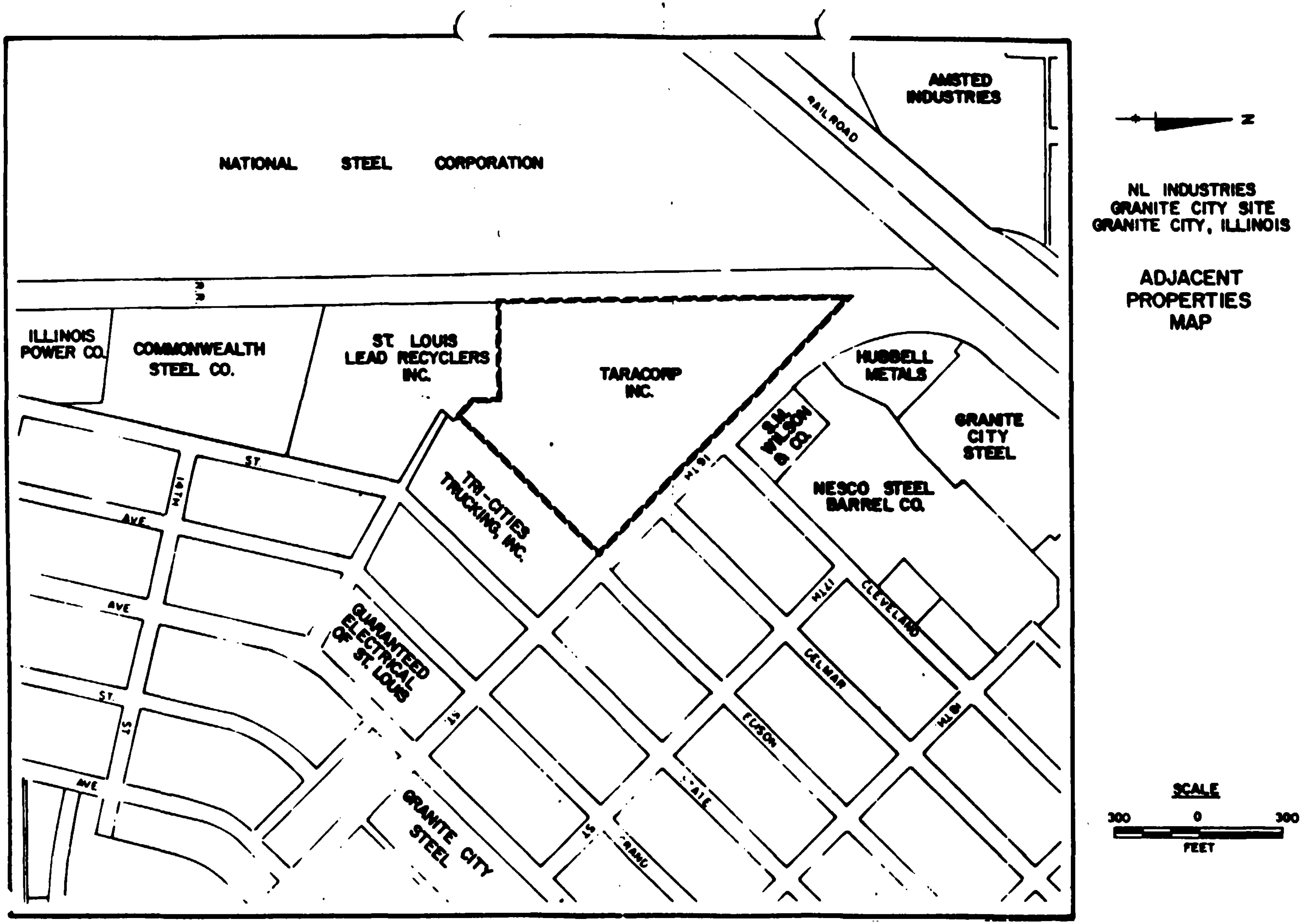


FIGURE 2 - ADJACENT PROPERTIES MAP

Source: O'Brien and Gere, 1988

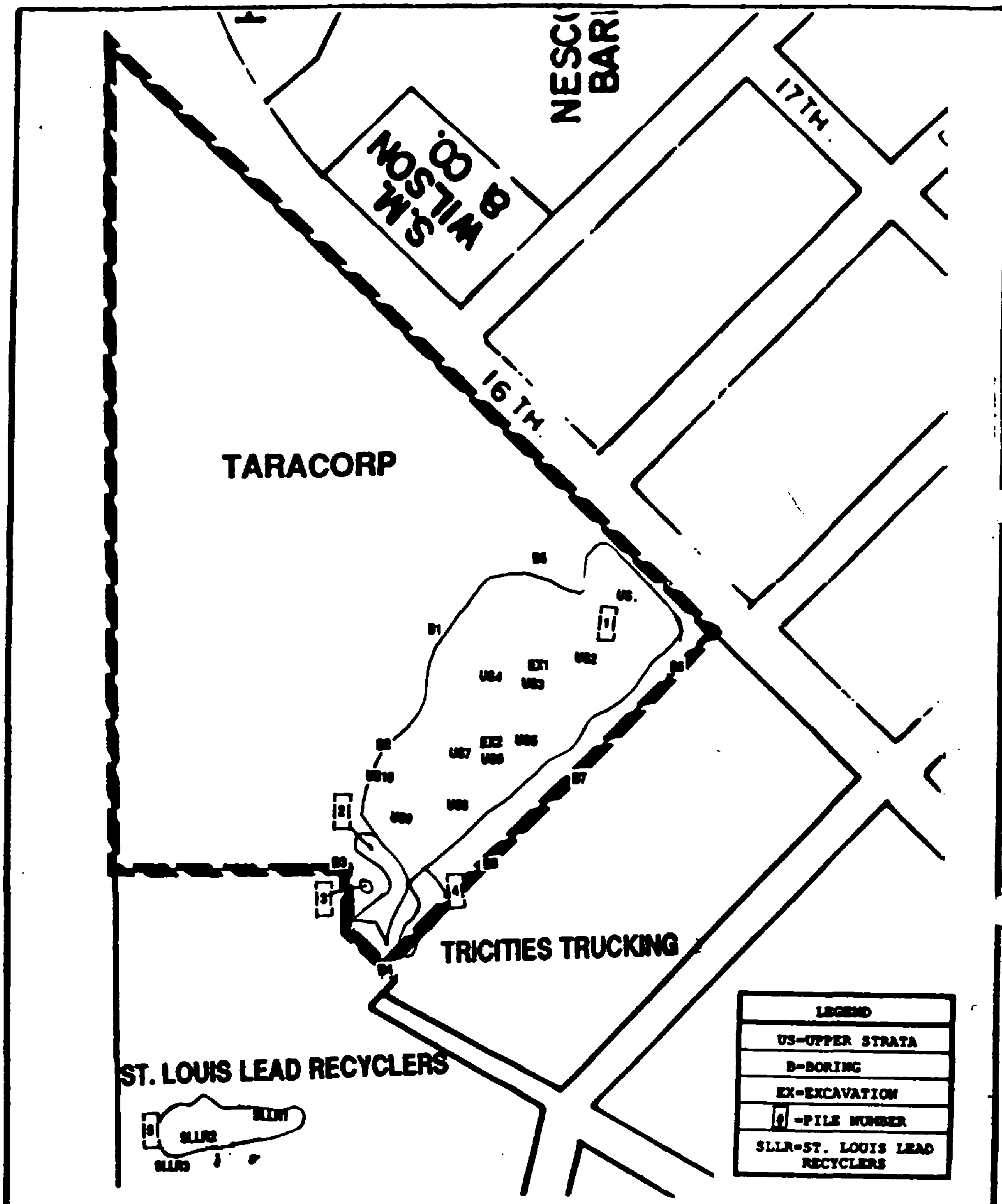


FIGURE 3 - ON-SITE WASTE SAMPLE LOCATIONS

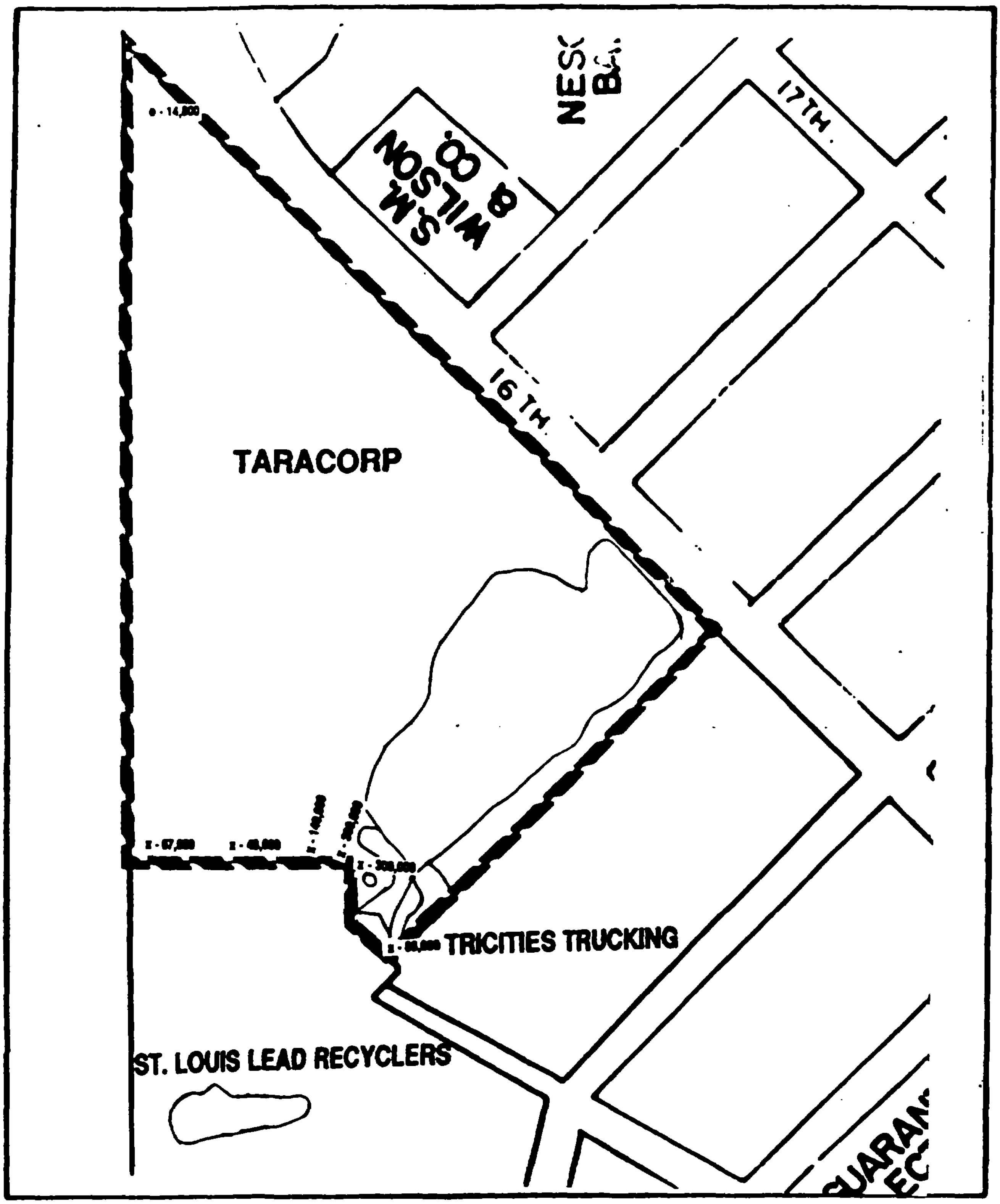


FIGURE 4 - ON-SITE SURFACE SOIL LOCATIONS

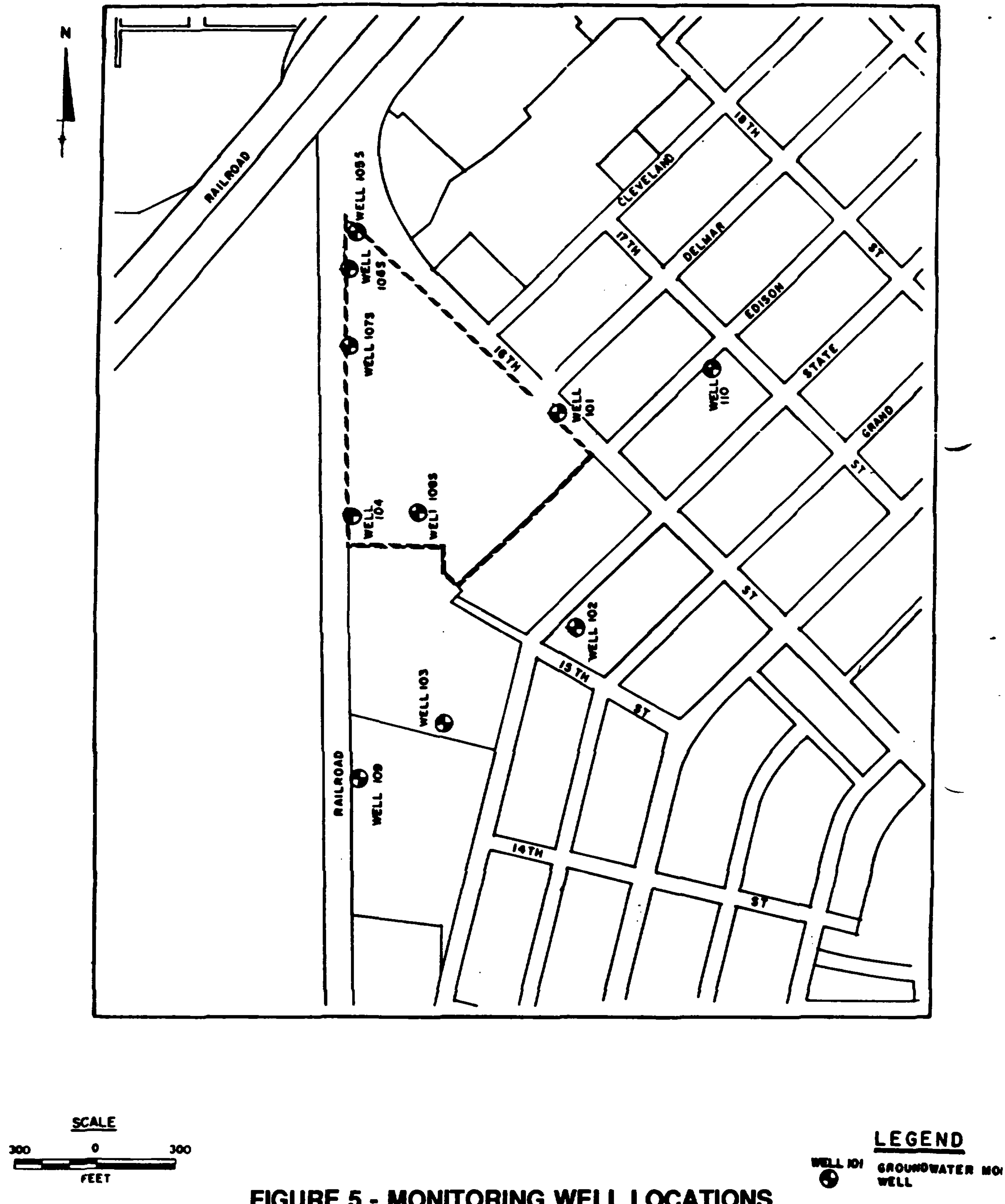


FIGURE 5 - MONITORING WELL LOCATIONS

Source: O'Brien and Gere, 1988

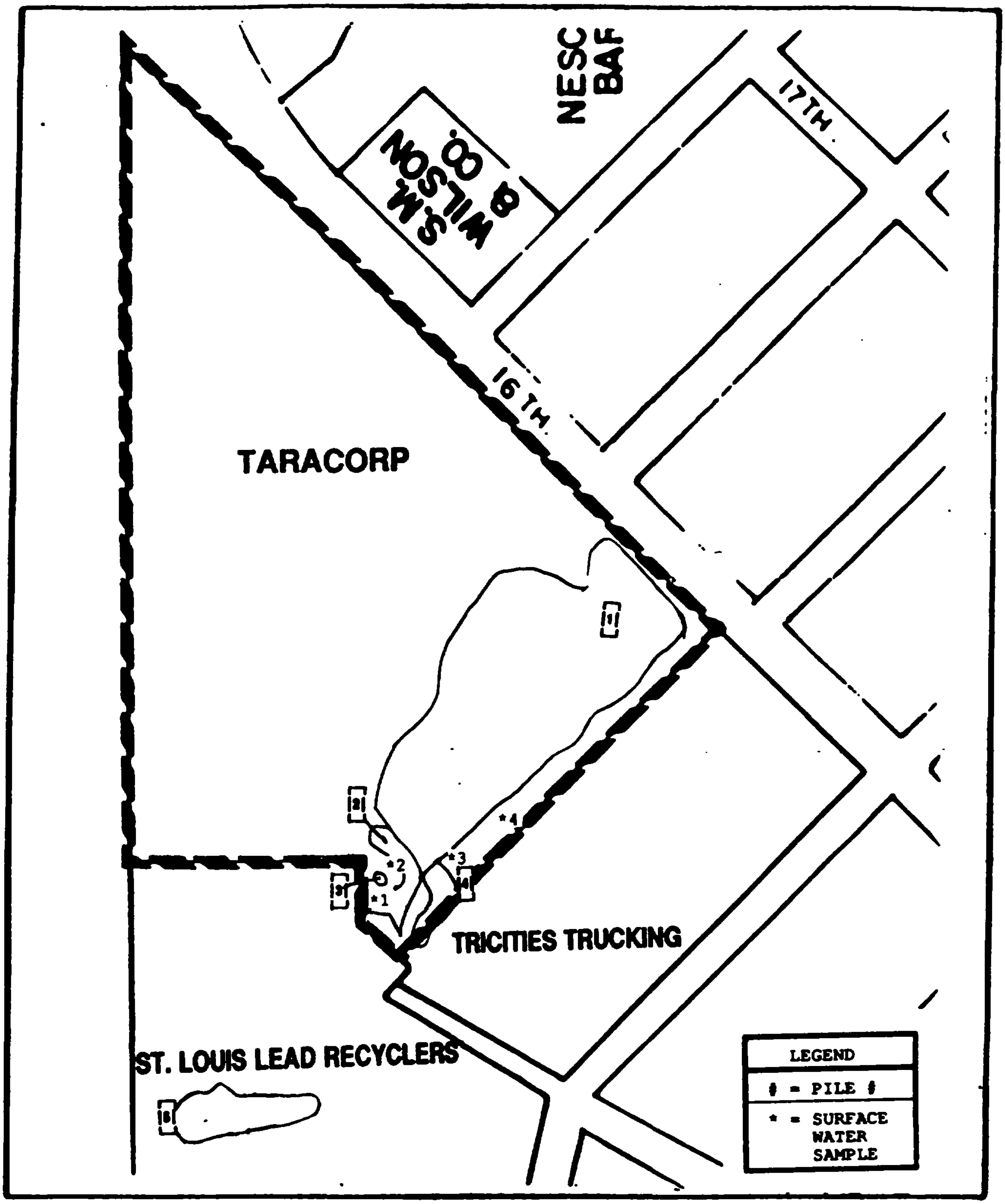


FIGURE 6 - STORM WATER AND STORM WATER SEDIMENT SAMPLE LOCATIONS

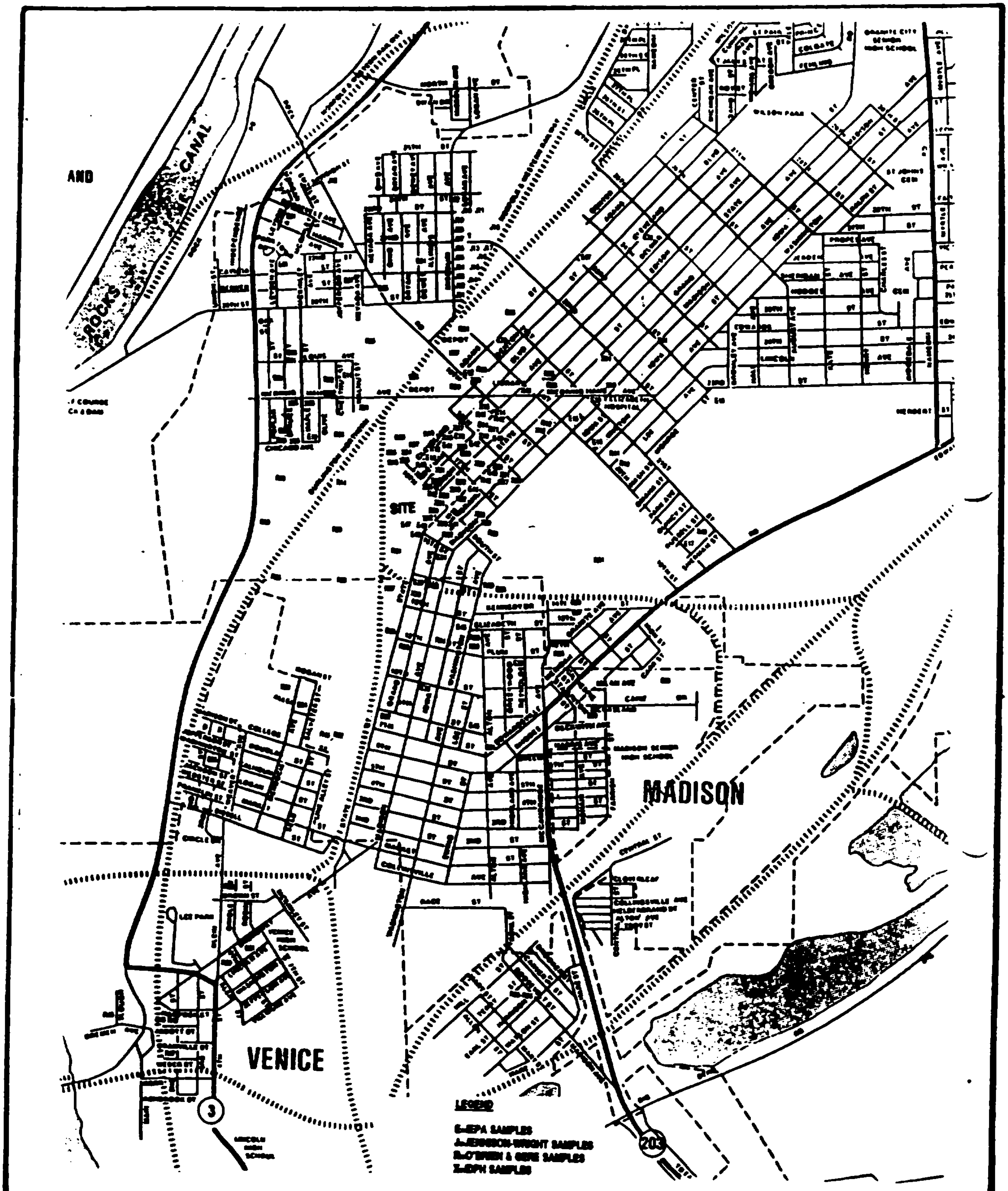


FIGURE 7 - OFF-SITE SURFACE SOIL SAMPLE LOCATIONS

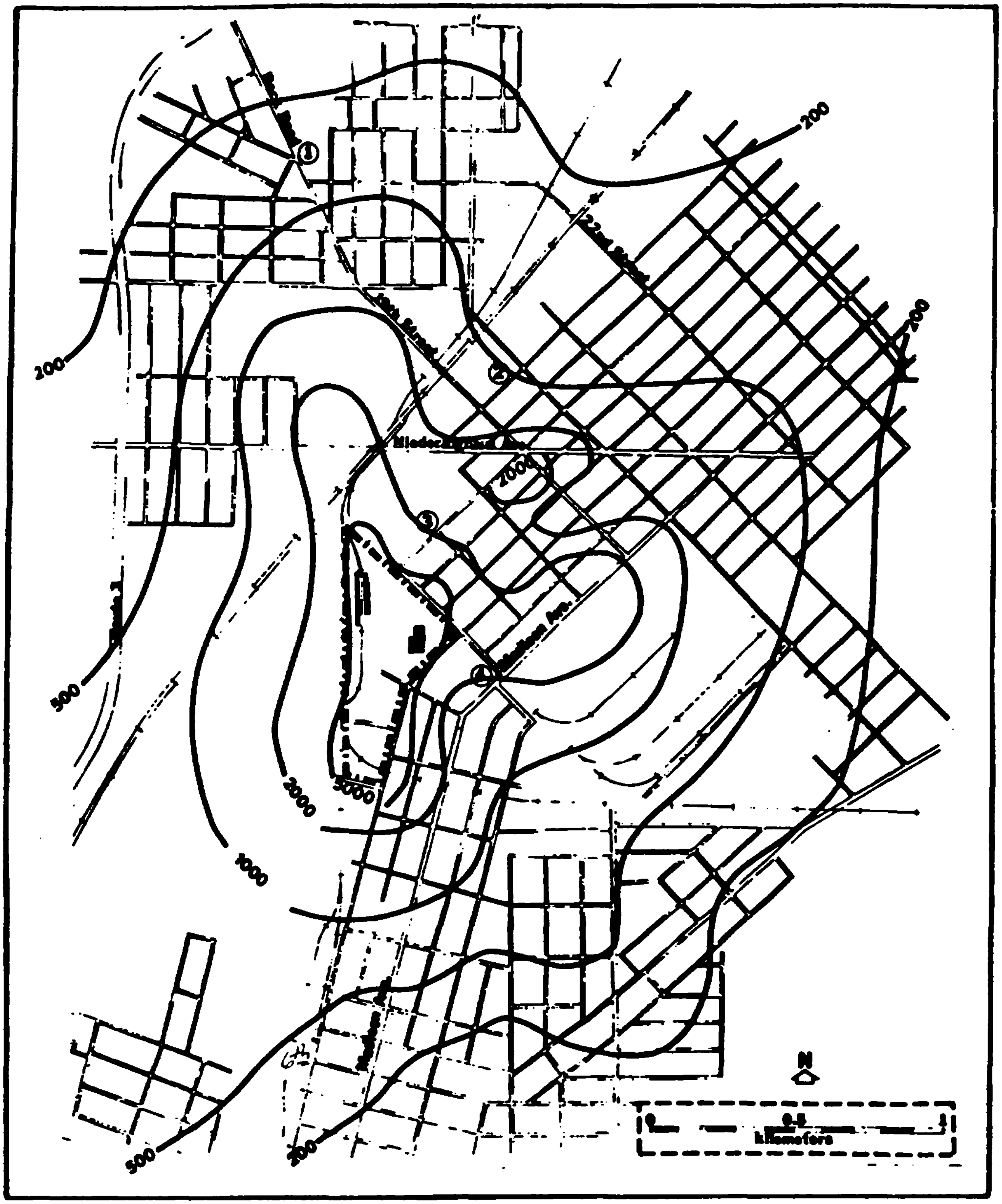


FIGURE 8 - LEAD CONCENTRATIONS MAP

Source: IEPA, 1983

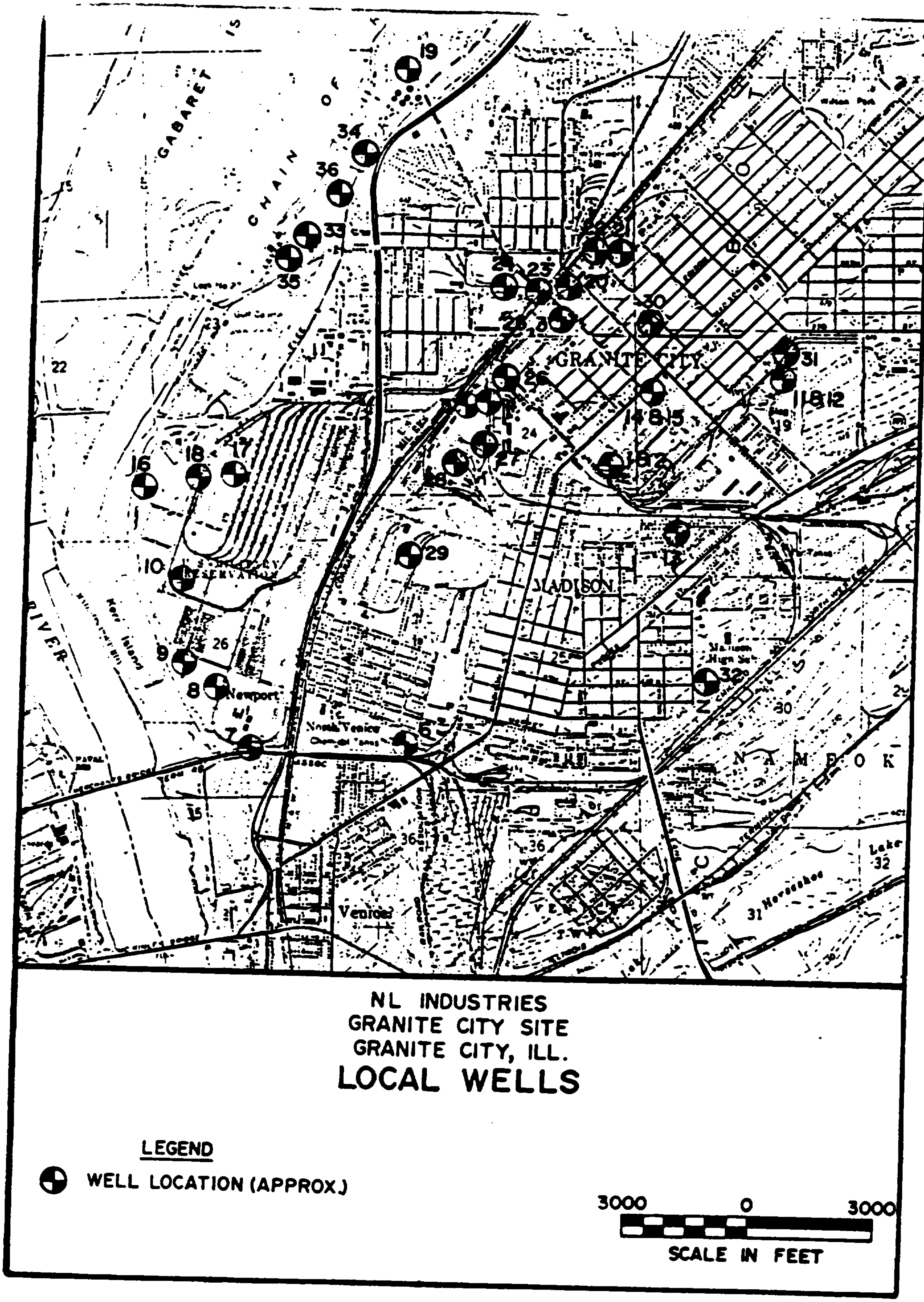


FIGURE 9 - OFF-SITE WELL LOCATION MAP

Source: O'Brien and Gere, 1988

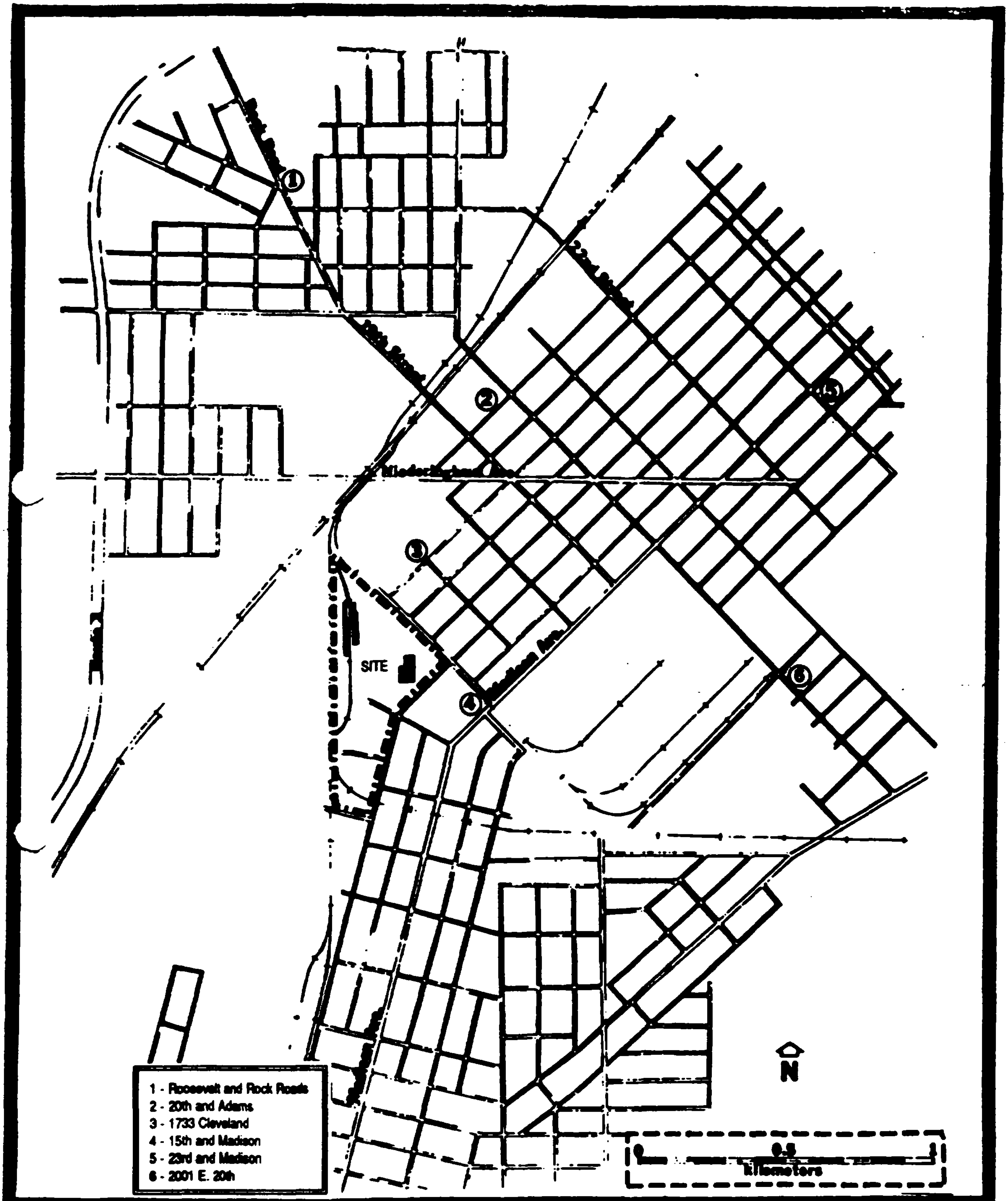


FIGURE 10 - AMBIENT AIR MONITORING LOCATIONS

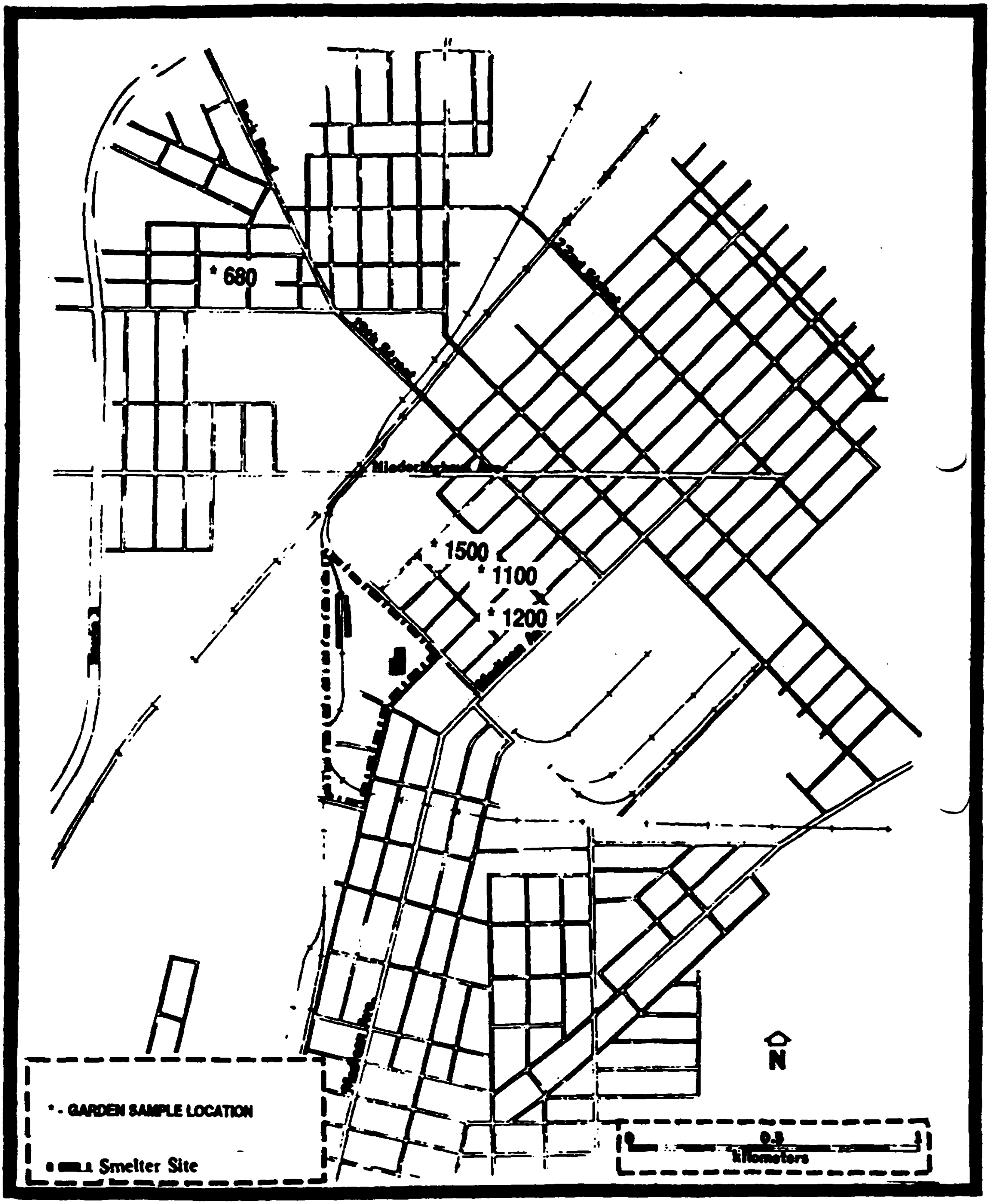


FIGURE 11 - GARDEN SAMPLE LOCATIONS

APPENDIX B. TABLES

The tables in this section contain the following acronyms and abbreviations:

EPA = U.S. Environmental Protection Agency

IDPH = Illinois Department of Public Health

Illinois EPA = Illinois Environmental Protection Agency

CREG = Cancer Risk Evaluation Guide

EMEG = Environmental Media Evaluation Guide

LTHA = Lifetime Drinking Water Health Advisory

ND = No Data

PMCLG = Proposed Maximum Contaminant Level Goal

PPM = Parts Per Million

RFD = Reference Dose

ICRC = Inhalation Cancer Risk Concentration

REF = Data Reference

FREQ = Number of Times the Sample Concentration was above the Comparison Value per Number of Samples

TABLE 1. 1993 Toxic Release Inventory data for zip codes 62040, 62060, 62090.

Company	Compound	Air Release (lbs/yr)	Water Release (lbs/yr)	Land Disposal (lbs/yr)	Total
Affiliated Metal Co.	Sulfuric acid	No Data	0	0	0
Air Products Mfg. Corp.	Sulfuric acid	6	No Data	0	6
Reilly Ind. Inc.	Anthracene	1.000	No Data	0	1.000
Reilly Ind. Inc.	Benzene	11.330	No Data	0	11.330
Reilly Ind. Inc.	Biphenyl	1.000	No Data	0	1.000
Reilly Ind. Inc.	Cresol	1.000	No Data	0	1.000
Reilly Ind. Inc.	Naphthalene	3.443	No Data	0	3.443
Reilly Ind. Inc.	Phenol	33.330	No Data	0	33.330
Reilly Ind. Inc.	Xylene	1.425	No Data	0	1.435
Taracorp Ind.	Lead	50	No Data	0	50
Taracorp Ind.	Antimony	0	No Data	0	0
Precoat Metals	Methyl Ethyl Ketone	31.652	No Data	0	31.652
Precoat Metals	N-Butanol	10.829	No Data	0	10.829
Precoat Metals	Toluene	1.371	No Data	0	1.371
Precoat Metals	Xylene	13.356	No Data	0	13.356
Precoat Metals	Methyl Isobutyl Ketone	3.378	No Data	0	3.378
Precoat Metals	Glycol Ethers	26.811	No Data	0	26.811
Precoat Metals	Antimony	176	No Data	0	176
Precoat Metals	Chromium	701	No Data	0	701
Granite City Steel	Aluminum	6.040	10.000	210.064	226.104
Granite City Steel	Ammonia	21.900	47.000	0	68.900
Granite City Steel	Anthracene	350	0	0	350
Granite City Steel	Barium	1.008	4.200	5.100	10.308
Granite City Steel	Benzene	22.000	5	0	22.005
Granite City Steel	Chromium	550	650	191.100	192.300
Granite City Steel	Copper	772	580	4.910	6.262
Granite City Steel	Cresol	675	0	0	675
Granite City Steel	Cyanide	290	950	0	1.240
Granite City Steel	Dibenzofuran	274	0	0	274
Granite City Steel	Ethylene Glycol	49.000	310	5.300	54.610

Granite City Steel	Ethylene	18.500	No Data	0	18.500
Granite City Steel	Hydrochloride Acid	4.900	0	15	4.915
Granite City Steel	Ethylbenzene	743	0	0	743
Granite City Steel	Lead	1.470	635	101.000	103.105
Granite City Steel	Manganese	9.300	9.000	576.000	594.300
Granite City Steel	Methanol	94.000	No Data	35	94.035
Granite City Steel	Naphthalene	1.960	2	0	1.962
Granite City Steel	Phenol	445	400	0	845
Granite City Steel	Phosphoric Acid	30.000	0	110	30.110
Granite City Steel	Sulfuric Acid	820	0	360	1.180
Granite City Steel	Toluene	3.600	0	0	3.600
Granite City Steel	Xylene	1.700	0	0	1.700
Granite City Steel	Zinc	98.000	3.000	3.569.000	3.670.000
Granite City Steel	Chlorine	4.255	660	0	4.915
Granite City Pickling	Hydrochloric Acid	3.050	No Data	0	3.050
Am. Steel Foundries	Chromium	0	No Data	0	0
Heidtman Steel Product	Chromium	5	No Data	0	5
Heidtman Steel Product	Nickel	5	No Data	0	5
Heidtman Steel Product	Hydrochloric Acid	1.000	No Data	0	1.000
Spectralite Consortium	Chromium	255	No Data	0	255
Spectralite Consortium	Zinc	1.500	No Data	0	1.500
Spectralite Consortium	Copper	1.000	No Data	0	1.000
Spectralite Consortium	Manganese	500	No Data	0	500
TOTALS		520.725	77.392	4.662.979	5.261.121

TABLE 2. Chemicals of interest in on-site waste pile slag.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
COPPER	5800-11000	1/87	32	ND	ND
LEAD	15000-37300	1/87	32	ND	ND
ZINC	2430-11170	1/87	32	ND	ND
ARSENIC	620-2200	1/87	32	210	RFD
ANTIMONY	410-1600	1/87	32	280	RFD

* - Mercury concentrations below detection limits

TABLE 3. Extraction Procedure (EP) toxicity for slag samples from the largest pile.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	EP TOXIC MAXIMUM CONTAMINANT LEVEL
ARSENIC	<0.005-0.021	1/87	32	5.0
CADMIUM	0.02-0.06	1/87	32	1.0
CHROMIUM	<0.05*	1/87	32	5.0
LEAD	147-312	1/87	32	5.0

* - All Chromium Samples <0.05 Note: Results in mg/kg

TABLE 4. Analyses of the upper layers of the largest waste pile.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
CADMIUM	6-6400	1/87	32	140	EMEG
COPPER	2.9-5600	1/87	32	ND	ND
LEAD	45000-279000	1/87	32	ND	ND
MERCURY	<0.5-1.6	1/87	32	ND	ND
ZINC	15.3-13840	1/87	32	ND	ND
ARSENIC	130-2200	1/87	32	210	RFD
ANTIMONY	630-6400	1/87	32	280	RFD

TABLE 5. Extraction Procedure (EP) toxicity for upper layer samples.

CONTAMINATION	CONCENTRATION RANGE (ppm)	DATE	REF	EP TOXIC MAXIMUM CONTAMINANT LEVEL
ARSENIC	<0.005-0.019	1/87	32	5.0
CADMIUM	<0.02-6.3	1/87	32	1.0
CHROMIUM	<0.05*	1/87	32	5.0
LEAD	<0.63-69	1/87	32	5.0

* - All Chromium Samples <0.05

TABLE 6. Chemicals of interest in the SLLR waste pile surface materials.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
CADMIUM	15-7000	1/87	32	140	EMEG
COPPER	260-4900	1/87	32	ND	ND
LEAD	105000-286000	1/87	32	ND	ND
MERCURY	<0.5-2.0	1/87	32	ND	ND
ZINC	383-42100	1/87	32	ND	ND
ARSENIC	5.6-4100	1/87	32	210	RFD
ANTIMONY	200-2900	1/87	32	280	RFD

TABLE 7. Extraction Procedure (EP) toxicity for SLLR surface materials.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	EP TOXIC MAXIMUM CONTAMINANT LEVEL
ARSENIC	0.108	1/87	32	5.0
CADMIUM	0.04	1/87	32	1.0
CHROMIUM	<0.05	1/87	32	5.0
LEAD	160	1/87	32	5.0

TABLE 8. Chemicals of interest in drummed material.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
CADMIUM	18-2700	1/87	32	140	EMEG
COPPER	89*	1/87	32	ND	ND
LEAD	237000-239500	1/83	27	ND	ND
MERCURY	106*	1/87	32	ND	ND
ARSENIC	3.7-400	1/83	27	210	RFD
ANTIMONY	81*	1/87	32	280	RFD

* - ONLY ONE DRUMMED SAMPLE ANALYZED FOR THIS CHEMICAL

TABLE 9. Extraction Procedure(EP) toxicity for drummed materials.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	EP TOXIC MAXIMUM CONTAMINANT LEVEL
ARSENIC	0-<0.005	1/87	32	5.0
CADMIUM	<0.01-15.5	5/83	27	1.0
CHROMIUM	<0.05	1/87	32	5.0
LEAD	41-1900	1/87	32	5.0

TABLE 10. Chemicals of interest for on-site surface soil.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
LEAD	14800-300000	1/87	32	ND	ND
ZINC	142*	1/87	32	ND	ND

* ONLY ONE ON-SITE SURFACE SOIL SAMPLE WAS ANALYZED FOR THESE COMPOUNDS.

TABLE 11. Chemicals of interest for on-site subsurface soils.

DEPTH	CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
1'-20'	LEAD	9-2700	1982	27	ND	ND
	ZINC	27-2200	1983	28	ND	ND
>20'	LEAD	7-67	1983	28	ND	ND
	ZINC	20-250	1983	28	ND	ND

TABLE 12. On-site monitoring well information.

WELL	INSTALLATION DATE	INSTALLER	SUBSURFACE SOIL SAMPLES	SAMPLING DATES
101	NOV. 1982	TARACORP	YES	11/82; 1/83; 2/83; 6/83; 8/83; 10/83; 1/87; 4/87; 8/87; 11/87
104	NOV. 1982	TARACORP	NO	11/82; 1/83; 2/83; 6/83; 8/83; 10/83; 1/87; 4/87; 8/87; 11/87
105S	JULY 1983	Illinois EPA	YES	8/83; 11/83; 1/87; 4/87; 8/87; 11/87*
105D	JULY 1983	Illinois EPA	NO	
106S	JULY 1983	Illinois EPA	YES	
106D	JULY 1983	Illinois EPA	NO	
107S	JULY 1983	Illinois EPA	YES	
107D	JULY 1983	Illinois EPA	NO	
108S	JULY 1983	Illinois EPA	YES	
108D	JULY 1983	Illinois EPA	NO	

* All wells constructed in July 1983 were sampled on the six dates shown in the last column.

TABLE 13. Chemicals of interest in on-site wells.

CONTAMINANT	RANGE (ppm)	FREQ	WELL #	DATES	REF	COMPARISON VALUE	
						(ppm)	SOURCE
CADMIUM	0-17	11/44	105D 106S&D 108S&D	83 87	27 32	0.007	EMEG
SULFATE	100-2950	15/45	101 107S&D 108S&D	83 87	27 32	400	PMCLG
LEAD	0-0.06	16/40*	101 104 106D 107S&D 108S&D	83 87	27 32	0.015	USEPA action level
NICKEL	0-0.1	9/45	107D 108S&D	83 87	27 32	0.1	LTHA
ARSENIC	0-0.1	11/45	101 107D	83 87	27 32	0.011	RFD

* Frequency of detection.

TABLE 14. Personal air monitoring program lead exposure for 1987.

DEPARTMENT	RANGE (mg/m^3)	#SAMPLES/ #QUARTERS	#PERSON IN DEPT.
Mixed Metals "A"	0.005-2.71	42/52	13
Mixed Metals "A" Dross	0.105-1.03	5/12	2
Mixed Metals "B"	0.005-0.194	33/32	8
General Services	0.00-0.215	17/20	5
Maintenance	0.002-6.76	40/40	10
Powdered Metal/Flux	0.016-2.59	20/20	5
Shot	0.002-1.61	52/41	13
Brittania	0.00-0.057	12/16	4
Sheet Lead/Lead Wool	0.008-0.132	9/20	5
Sheet Lead	0.002-0.274	41/60	15
Extrusion	0.00-0.09	56/56	14
Staff	0.002-0.072	11/10	5

TABLE 15. 1987 Personal air monitoring program for arsenic exposure at Taracorp.

DEPARTMENT	RANGE (mg/m³)	# OF EMPLOYEES	# SAMPLES/ # QUARTERS
Mixed Metals A	0.00008-0.121	13	42/52
Mixed Metals A"Dross"	0.0009-0.014	3	5/12
General Services	0.0005-0.002	1	4/4
Maintenance	0.0004-1.32	1	4/4
Shot	0.00-0.061	8	16/32

TABLE 16. Lead in environmental samples: soil, dust, and water.

Environmental sample	N	Mean Lead	Minimum	Maximum	Standard Deviation
Soil-dry composite	375	450	37	3,010	411
Dust by weight (mg/kg)	371	1,283	5.2	71,000	5,236
Dust by surface (μg/m²)*	367	885	1.6	58,800	4,489
Tap water μg/L (ppb)	373	3.3	<2	96	8
Indoor paint (mg/cm²)**	372	1.2	0	10.4	1.6
Outdoor paint (mg/cm²)**	380	5.3	0	31.2	6.4

*The "dust load" was calculated by dividing the dust sample weight by the surface area vacuumed and multiplying this ration by the dust lead concentration.

** The paint values represent means of 18 indoor and 12 outside readings. Readings of zero were included in the calculations.

TABLE 17. Chemicals of interest in off-site surface soils.

CONTAMINANT	CONCENTRATION RANGE (ppm)	DATE	REF	COMPARISON VALUE (ppm)	SOURCE
CADMIUM	0.4-15.7	1989	11	0.4	EMEG
CHROMIUM	3-150	1989	27	10	RFD
LEAD	2-9493	1983	11	ND	ND
NICKEL	14-84	1989	11	40	RFD
ZINC	13-4000	1983	27	ND	ND
ANTIMONY	2-80	1983	27	0.8	RFD
ARSENIC	1-1845	1989	11	0.6	RFD

TABLE 18. Surface soil data for lead.

RADIUS IN MILES	RANGE (ppm)	NUMBER OF SAMPLES	COMMON RANGE IN SOIL (ppm)
0-1/4	145-9493	40	2-200
1/4-1/2	91-5034	48	2-200
1/2-3/4	116-2940	40	2-200
3/4-1	2-570	23	2-200

TABLE 19. Chemicals of interest in off-site wells

CONTAMINANT	RANGE (ppm)	DATES	REF	COMPARISON VALUE (ppm)	SOURCE
CADMIUM	0-0.002	1987	32	0.002	EMEG
SULFATE	100-2950	1983	27	400	PMCLG
LEAD	0-0.28	1987	32	0	PMCLG
BORON	0.2-1.6	1983	27	0.9	RFD
MANGANESE	0.0-1.06	1987	32	1.0	RFD

TABLE 20. Air monitoring results for lead from 1977-1990 ($\mu g/m^3$)

LOCATION	77	78	79	80	81	82	83	84	85	86	87	88	89	90
2000 Edison	1.09	0.84	0.8	-	-	-	-	-	-	-	-	-	-	-
23rd and Madison	1.09	0.88	0.8	0.47	0.43	-	0.35	0.29	0.2	0.17	0.2	0.12	0.13	0.13
3201 E. 23rd	0.7	0.69	0.68	-	-	-	-	-	-	-	-	-	-	-
2001 E. 20th	0.7	1.11	1.08	0.52	0.51	-	-	-	0.23	0.19	0.2	0.13	0.16	0.16
15th and Madison	2.08	3.2	2.71	1.75	3.03	1.36	0.63	0.75	0.38	0.31	0.3	0.26	0.24	0.21
Roosevelt & Rock Park	1.02	1.26	1.25	0.82	0.83	1.23	0.37	0.29	0.2	-	-	-	-	-
2040 Johnson Road	0.82	0.74	0.64	0.39	0.34	-	-	-	-	-	-	-	-	-
E. 23rd and Nameoki	1.03	0.94	0.96	0.52	0.47	-	-	-	-	-	-	-	-	-
Norfolk and Western	0.41	0.57	0.48	0.31	0.31	-	-	-	-	-	-	-	-	-
19th & Adams	-	3.0	1.4	0.55	0.78	0.7	0.42	0.27	0.19	0.16	-	-	-	-
20th & Adams	-	-	-	-	0.68	0.71	0.4	0.27	0.18	0.16	-	-	-	-
17th and Cleveland	-	-	-	-	-	-	0.78	0.58	0.33	0.33	0.32	-	-	-

TABLE 21. Off-site contamination concentrations in air for the years 1977-1982.

CHEMICAL	CONC. RANGE USING YEARLY ARITHMETIC MEANS ($\mu g/m^3$)	HIGH YEAR	SITE	REF	COMPARISON VALUE ($\mu g/m^3$)	SOURCE
CADMIUM	0.0045-0.011	78	6	13	0.2	EMEG
COPPER*	0.12-0.29	78	1	-	ND	ND
LEAD	0.41-3.2	78	4	13	ND	ND
ZINC*	0.35-1.67	77	5	12	ND	ND
ARSENIC	0.004-0.039	78	4	13	0.00023	ICRC
MANGANESE	0.153-1.335	78	6	13	2.0	EMEG

* Copper and zinc were only sampled in 1977 and 1978. Selenium and nickel were not analyzed in the samples until 1984. Chromium was not analyzed in samples until 1985.

TABLE 22. Off-site contamination concentrations in air for the years 1983-1990.

CHEMICAL	CONC. RANGE USING YEARLY ARITHMETIC MEANS ($\mu g/m^3$)	HIGH YEAR	SITE	REF	COMPARISON VALUE ($\mu g/m^3$)	SOURCE
LEAD	0.12-0.78	83	3	18	ND	ND
ARSENIC	0.002-0.019	84	4	19	0.00023	ICRC
NICKEL	0.001-0.021	88	6	23	0.009	EMEG
SELENIUM	0.002-0.006	89	6	24	ND	ND
CHROMIUM	0.002-0.032	87	6	22	0.02*	EMEG

* - Based on Chromium VI

TABLE 23. Vegetable analyses.

SAMPLE	LEAD CONCENTRATIONS (ppm)					
SOIL	1500	1200	1100	680	97**	53
TOMATOES	0.122	0.035	0.066	0.028	0.007	0.005
PEPPERS	0.119	0.053	-	-	0.007	-
BANANA PEPPERS	0.134	-	-	-	0.010	0.010
OKRA	-	-	0.128	0.641	0.014	0.020
CAULIFLOWER*	0.198	-	-	-	-	-
CARROTS	-	-	0.392	-	-	-
CABBAGE	-	0.633	-	-	-	-
CUCUMBER	-	0.083	-	-	-	-
PEAS	-	-	-	-	-	0.002
SQUASH	-	-	-	0.124	-	-
BEETS	-	-	-	0.087	-	-
BEET LEAVES	-	-	-	0.058	-	-
EGGPLANT	-	-	0.048	-	-	-

* The cauliflower was frozen
** The vegetables in the 97 ppm column were collected from two gardens across the street from each other. A soil sample was taken from only one garden.

Source: Illinois EPA, 1982 (Reference #27)

Table 24 - Distribution of blood lead levels (BPbs) by age of participant*.

Age of Participant	**6-71 Months**	**6-15 Years**	**>15 Years**	**Total**
Total Number	490	214	123	827
Male	261	111	47	419
Female	229	103	76	408
Mean BPb** µmol/L µg/dL	0.33 6.9	0.21 4.4	0.17 3.6	0.28 5.8
Range BPb µmol/L µg/dL	0.03 - 1.94 0.7 - 40.2	<0.03 - 0.90 <0.6 - 18.8	0.30 - 0.86 <0.6 - 17.9	<0.03 - 1.94 <0.6 - 40.2
≥ 0.48 µmol/L (10 µg/dL)	78	8	3	89

*Nine children included in this table lived at their present residence less than 3 months at the time of the study.
**BPb = blood lead

Table 25 - Distribution of blood lead levels in children from 6 months to 6 years of age with blood lead levels $\geq$ 0.48 μmol/L ($\geq$ 10 μg/dL).

Blood Lead Level	Number	Percent of Total 490 Children
$\geq$ 0.48 µmol/L ($\geq$ 10 µg/dL)	78	16
$\geq$ 0.48 µmol/L and <0.72 µmol/L ($\geq$ 10 µg/dL and <15 µg/dL)	46	9
$\geq$ 0.72 µmol/L and 1.21 µmol/L ($\geq$ 15 µg/dL and <25 µg/dL)	27	5.5
$\geq$1.21 µmol/L ($\geq$25 µg/dL)	5	1

TABLE 26. Completed exposure pathways.

Pathway Name:	Source	Medium	Exposure Point	Exposure Route	Receptor Population	Time of Exposure	Exposure Activities	Estimated Number Exposed	Chemicals
On-site surface soil	Waste piles Site operations On-site soil	Surface soil	On-site soil	Ingestion Inhalation	Employees and visitors	Past Present Future	Contacting contaminated soil	50	Lead & other site-related metals
Off-site surface soil	Waste piles Site operations Off-site soil	Surface soil	Yards Play-grounds	Ingestion Inhalation	Residents Playground users	Past Present Future	Playing in & working with contaminated soil	8,000	Lead & other site-related metals
Ambient Air	Waste piles Site operations Contaminated soil	Air	Residents closest to the site	Inhalation	Nearby residents	Past Present Future	Breathing	8,000	Lead & other site-related metals
Vegetables	Contaminated soil Air deposition	Fruits & Vegetables	Gardens	Ingestion	Residents with gardens or fruit trees	Past Present Future	Eating fruits & vegetables without cleaning	800	Lead & other site-related metals
Waste Piles	Waste piles	Waste pile	Employees	Ingestion Inhalation	On-site Workers	Past Present Future	Working with the waste piles	10	Lead & other site-related metals

TABLE 27. Potential exposure pathways.

Pathway Name:	Source	Medium	Exposure Point	Exposure Route	Receptor Population	Time of Exposure	Exposure Activities	Estimated Potential Number Exposed	Chemicals
Private Wells	Waste pile Contaminated soil	Ground-water	Residents closest to the site	Ingestion	Residents drinking contaminated well water	Past Present Future	Drinking contaminated well water	120	Lead & other site-related metals
Surface water	Waste piles Contaminated soil	Surface Water	Residents closest to the site	Ingestion	Persons ingesting storm water.	Past Present Future	Playing in storm water	80	Lead & other site-related metals
Waste pile	Waste pile Contaminated soil	Waste pile	Remediation Worker	Ingestion Inhalation	Workers remediating the pile and soils	Future	Remediating the waste pile and soils	30	Lead & other site-related metals

TABLE 28. Comparison of estimated off-site soil contaminant exposures to health guidelines.

CONTAMINANT	HEALTH GUIDELINE (mg/kg/day)		EXCEEDED/GROUP
	VALUE	SOURCE	
LEAD	NONE	NONE	UNKNOWN
ARSENIC	0.0003	ORAL RFD	YES/ADULT, CHILD, PICA CHILD
ANTIMONY	0.0004	ORAL RFD	YES/PICA CHILD, CHILD
CADMIUM	0.0002	CHRONIC ORAL MRL	YES/PICA CHILD, CHILD
CHROMIUM*	0.005	ORAL RFD	YES/PICA CHILD
NICKEL**	0.02	ORAL RFD	YES/PICA CHILD
ZINC	NONE	NONE	UNKNOWN

* - CHROMIUM AS CHROMIUM VI
** - NICKEL AS SOLUBLE SALTS
MRL - MINIMUM RISK LEVEL